ARI Contractor Report 2000-02

Simulation Training Strategies for Force XXI

J. Ward Keesling
PRC, Inc.

James King and William J. Mullen III
BDM Federal, Inc.

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November 1999

United States Army Research Institute for the Behavioral and Social Sciences

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1999	**Final Report 4/3/97-11/30/97**

4. TITLE AND SUBTITLE

Simulation Training Strategies for Force XXI Final Technical Report

5. FUNDING NUMBERS

MDA 903-92-D-0075-0050
2114
CO12
665803 D730

6. AUTHOR(S)

J. Ward Keesling, James King, and William J. Mullen III

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

BDM Federal Inc.
DOD Center Monterey Bay
400 Gigling Road
Seaside, CA 93955

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

US Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333-5600

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

CR 2000-02

11. SUPPLEMENTARY NOTES

The COR was Michael R. McCluskey

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for Public Release; Distribution is Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The project examined the notional suitability, feasibility, affordability, and deployability criteria for assessing training environments and developed: (1) A decision aid to assist in identification of training environments (live, virtual, constructive, or hybrid) that are suitable for training particular tasks or functions. (2) Procedures and guidance to assist in determining the sequence of training environments to employ to achieve and sustain proficiency of particular tasks or functions. This report summarizes these developments, highlighting the major concerns and considerations that influenced the developmental process. The first chapter provides overall background to the project. Chapter 2 discusses the development of the environment selection decision aid (ESELDA). Chapter 3 discusses the development of procedures to sequence training environments. Chapter 4 presents a discussion of the likely implications of future developments in simulation technology, and Chapter 5 presents concluding remarks and directions for further efforts.

14. SUBJECT TERMS

Training strategies, Force XXI, simulation, collective tasks, training environments, training sequences, future training trends and capabilities

15. NUMBER OF PAGES **70**

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	**UNCLASSIFIED**	**UNCLASSIFIED**	**UNLIMITED**

Contract #: MDA 903-92-D-0075
Deliverable #: 0050-03-0050AG

SIMULATION TRAINING STRATEGIES FOR FORCE XXI FINAL TECHNICAL REPORT

Submitted to:

Mr. Michael McCluskey,
Contracting Officer's Representative
United States Army Research Institute
for the Behavioral and Social Sciences

Submitted by:
BDM Federal, Inc.

Authors:

J. Ward Keesling
PRC, Inc.

James King
BDM Federal, Inc.

William J. Mullen III
BDM Federal, Inc.

February 5, 1998

FINAL TECHNICAL REPORT

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FINAL TECHNICAL REPORT

Chapter 1: Introduction

The project, Simulation Training Strategies for Force XXI, conducted under the technical supervision of the Army Research Institute (ARI), examined notional suitability, feasibility, affordability, and deployability criteria for assessing training environments and developed:

1. A decision aid to assist in identification of training environments (live, virtual, constructive, or hybrid) that are suitable for training particular tasks or functions.

2. Procedures and guidance to assist in determining the sequence of training environments to employ to achieve and sustain proficiency of particular tasks or functions.

This report summarizes these developments, highlighting the major concerns and considerations that influenced the developmental process. This chapter provides overall background to the project. Chapter 2 discusses the development of the environment selection decision aid (ESELDA). Chapter 3 discusses the development of the procedures to sequence training environments. Chapter 4 presents a discussion of the likely implications of future developments in simulation technology, and Chapter 5 presents concluding remarks and directions for further efforts.

Background

Some futurists believe that by the year 2030 the U. S. Army will evolve to units that are small, autonomous, versatile, flexible, and highly lethal. Robotics, brilliant weapons, sensors, emitters, and mini-projectiles will work in concert to detect, track, and land a weapon of destruction on any target. The importance of individual soldiers as sensors and target spotters will increase significantly; their units will rely on long range weapons for fires. Operations will not have clear fronts, and there will be very few tactical engagements. Whether or not these predictions prove to be correct, it is certain that there will be changes in equipment, organization, and doctrine.

Army leaders face the challenge of managing the change from the present to their vision of the future within the constraints of technology, economic and political realities. The Army is faced with declining resources, yet must evolve as a smaller force which is more flexible, versatile, lethal, and relevant. The Army plans to meet this challenge with the Force XXI vision of future warfighting. Of particular concern is the development of the training systems to support the future Army. As the Army Training XXI Campaign Plan (Schmidt, 1997) notes:

> To realize (future warfighting) potential, the Army must develop and field a total Army training system that best enables the soldiers, leaders, and organizations to employ the Army's full capabilities. Army Training XXI will employ state-of-the-art information

technologies in a fully integrated, networked, and internetted training support system to provide realistic, timely, user-responsive, and cost-effective training for units, individuals, and institutions.

The guidelines for managing the decentralized community of planners, developers, and trainers are articulated in the TRADOC Requirements Determination Pamphlet (1997), which is a top-level strategy to manage and control requirements by establishing centralized control of resources while maintaining the power of decentralized efforts to reach the centrally determined goals.

Typically, there is an array of solutions that can be used to train soldiers and units; choices must be made about which one or ones to develop to support the future training needs. Decision aids can help focus reviews of requirements and milestone decisions in a meaningful way, and, thereby, integrate the efforts of trainers, training developers, and material developers. Decision aids also assist in standardizing the approach to appraising the merits of the different solutions.

General Approach

The overall approach to the project was to develop a decision aid to assist with assessing the degree to which different environments were appropriate for training different functions and tasks, then apply the results of that decision aid in developing further guidance for developing sequences of environments to be used in training. Because the decision aid for assessing the appropriateness of environments had to apply to a broad variety of units, echelons, functions, and tasks, a selection of these was needed for use in prototyping the decision aid and to test its face validity. For similar, practical reasons a selection had to be made from the very large number of equipment modernization systems projected to be available in the future. Practical limitations also led to sampling from the wide variety of different types of training exercises the Army has developed to accomplish collective training of units at all echelons.

The next part of this chapter discusses the training environments that had to be considered in developing the decision aid and sequencing guidance. The section following that presents the considerations leading to a selection of units, echelons, exercises, functions, tasks, and modernization systems for use in the development process. This chapter concludes with an overview of the remaining chapters.

Training Environments Considered

Four training environments were considered in this project: Live, virtual, constructive, and hybrid. Live simulations are of two types, both involving soldiers using assigned equipment: Live-fire exercises in which ammunition is fired at targets on ranges (Tank Gunnery Table VIII is an example), and force-on-force exercises that employ devices to simulate the firing of weapons, an engagement system to simulate weapons' effects (e.g., MILES, the Multiple Integrated Laser Engagement System), and instrumentation to record information about the fight.

Virtual simulations replicate, with varying fidelity, the equipment soldiers use to carry out their tasks. At the lower end of realism are procedural trainers (such as panel trainers); at the higher end are synthetic environments such as Simulation Networking (SIMNET), or the Close Combat Tactical Trainer (CCTT), and tank driver trainers. Constructive simulations also cover a wide range: Sand table and terrain map exercises are non-automated constructive simulations; examples of computer wargaming models, generally used to train commanders and staffs, are JANUS and the Battalion, Brigade Simulation (BBS).

Advances in computer and communications technologies have made it possible to create hybrids of these environments by linking and distributing simulations using a common synthetic battle space. The Synthetic Theater of War - Europe (STOW-E) and Army Experiment III (Immersive Theater and Force Projection Tactical Operations Center) are examples.

At the level of the individual weapon platform, there are also developments that are blending the live and virtual environments. The Tank Weapons Gunnery System (TWGS) and the Precision Gunnery System (PGS) both use devices to simulate weapons fire, and lasers to stimulate appropriate effects on opponent vehicles. TWGS and PGS represent the flight path and burst of the main gun round virtually (by means of a device applied to the target sight). These systems can be used against targets and actual vehicles, blurring the distinction between live-fire and force-on-force. PRIME, the Precision Range Integrated Maneuver Exercise, also may involve mixes of targets (some of which may have shoot-back capability) and real vehicles.

Embedded training systems may used to support any of these types of training environments. Embedded training systems maximize the realism of the man-machine interface by having the personnel being trained use their actual equipment to respond to the situations presented by the simulation. Three degrees of embedding are commonly recognized: 1) Integrated, in which the training system is fully integrated with the operational equipment; 2) attached, in which some of the training system may be detached and re-attached from the operational equipment, as needed; and 3) umbilical, in which some of the training system exists outside of the operational equipment and must be connected to it.

One vision of the path from the present, with separate simulation domains, to a future of integrated simulation systems is shown in Figure 1-1 (adapted from Skurka, 1997). The operational domains in Figure 1 are: Advanced Concept Requirements (ACR); Research, Development, and Acquisition (RDA); and Training, Exercises, and Military Operations (TEMO).

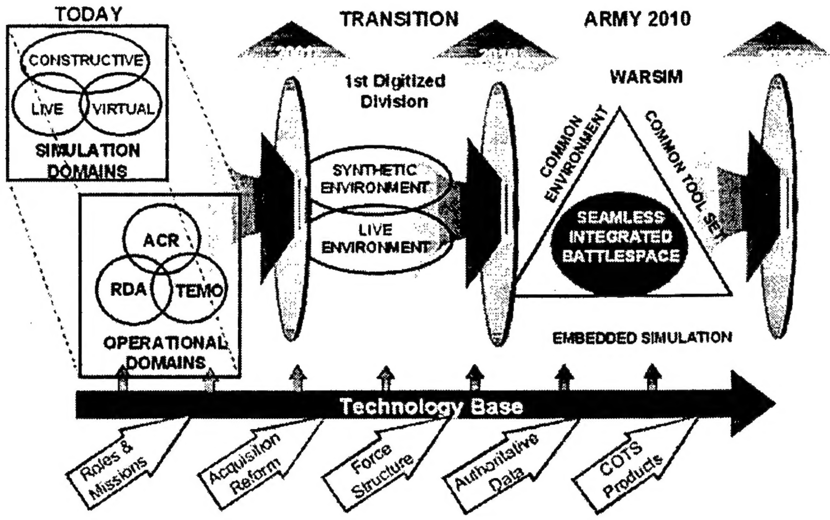

Figure 1-1. Evolution of training environments.

The examination of simulation systems undertaken for this project led to the development of additional insights and speculations about the future of simulation in Army training which are presented in Chapter 4, Future Trends and Capabilities. Appendix D, Information Sheets for Selected Simulations, provides more detailed descriptions of simulation capabilities considered in prototyping and testing the decision aid and sequencing guidance. These simulations are:

- War Simulation 2000 (WARSIM)
- Joint Simulation System (JSIMS)
- Combined Arms Tactical Trainer (CATT)
- One Semi Automated Forces (ONESAF)
- Aviation Reconfigureable Manned Simulator (ARMS)
- Home Station Training Instrumentation (HST)

Selection of Units, Echelons, Exercises, Functions, Tasks, and Modernization Systems

General

Given the wide array of unit types, functions, and tasks, as well as the great variety of present and planned examples of the different types of training environments, it was not possible to test the decision aids by assessing every possible instance of a training environment with respect to every possible function and task, while considering the impacts of all possible combinations of modernization systems. Therefore, the prototype decision aids and procedures were developed using a selection of unit types, echelons, exercises, functions, and tasks within those units that would best illustrate the use of the decision models. Similarly, modernization systems that would best illustrate the use of the decision models were also chosen.

The goals for the selection of units, echelons, exercises, functions, tasks, and modernization systems to be used in developing the prototype decision aids were:

- Span a number of different types of units, echelons, exercises, and functions so that these test cases would be sure to identify the necessary factors for inclusion in the decision aid.
- Choose examples of future systems that would be likely to have an impact on the tasks to be performed, the organization that would perform them, or the ability of the various environments to replicate the effects of these innovations.
- Limit the number of comparisons to a reasonable subset of all those that are possible.

The selection of specific units, echelons, functions, and exercises will be addressed below in separate sections. To provide a context for these selections, it is necessary to start with a baseline that addresses training requirements for many of the units and echelons of interest. The next section discusses the use of the unit short range Combined Arms Training Strategies (CATS) to provide this context.

Training Strategy

It is important to link simulation acquisition with training strategies, changes in DOTML, and improved simulation environments in a best value manner to avoid duplication and to meet the training objectives of Force XXI. Since the purpose of this project was to develop the prototype for two decision aids that will assist in this process, the exact units and simulations selected are not as important as is a baseline training strategy from which to evaluate the changes and provide an azimuth for projection into the future. The decision aids are intended to be notional and applicable at any echelon: Joint task force, corps, division, brigade, battalion, company, platoon, squad, crew, or individual. Practically, they must be evaluated in the context of an agreed upon training plan or strategy such as the unit short range Combined Arms Training Strategies (CATS), currently under development by TRADOC.

These CATS encompass the training principles outlined in FM 25-100, Training the Force, and provide a framework for Army training in units. The strategies group tasks (by mission and function) and integrate training for each echelon into a combined arms, multi-echelon, training program. CATS have been produced and accepted for the battalion level, and are being developed for brigades.

In addition to showing how the training cycles at various echelons coincide to produce a progressive training sequence from the individual through the entire brigade combat team, CATS provide information applicable to commanders making choices among training environments that they have at home station and while deployed. This information includes "gate" tasks which individuals and subordinate units must be able to perform at a specified level of proficiency in order to maximize the training value of an exercise, and to permit the exercise to be conducted safely. The CATS also describe the training environments for events and rate the quality of the events as performed in particular environments. The CATS also advise commanders to consider whether a particular environment will support training the gate tasks when they plan training.

Generally, CATS show each echelon progressing through a training program that makes use of progressively more realistic and demanding exercises. These are sequenced so that the lower echelon units become sufficiently proficient to profit from (or, sufficiently proficient that they do not disrupt) exercises at higher levels. Multi-echelon training allows lower echelon units to focus on the physical tasks such as moving and shooting, while, in separate exercises, the higher echelons focus on monitoring, planning, and directing operations while exercising command and control and leadership. As proficiencies develop, exercises are conducted that bring the higher echelon headquarters and subordinates together to train all their functions concurrently.

It seems unlikely that changes in the equipment or organization of the units in question will have profound effects on the foregoing training paradigm. Subordinate echelons will still need to train to a degree of proficiency in their specialty that will enable them to accomplish their own mission and to participate successfully in combined arms, multi echelon, exercises, culminating in an exercise that completes the training and validates the readiness status of the entire team. Training will continue to be organized as a sequence of exercises that trains clusters of tasks that are required to execute particular functions on the battlefield. What may change are the environments in which a task can and should be trained.

Since CATS is the Army's training baseline, this project took advantage of its maturity and acceptability by using it to develop and illustrate the decision aids.

Selection of Units

The Army's approach to training ground maneuver units changes emphasis at the transition between Battalion Task Force and Brigade Combat Team. As described in mission training plans, training for maneuver battalions and subordinate units emphasizes defeating the enemy through employment of maneuver and firepower, while training of maneuver brigades and higher echelons focuses on commander and staff functions, and the integration and synchronization of the performance of subordinate units. Similarly, CS and CSS training for lower echelons focuses on accomplishing tasks on the battlefield, while training for higher echelons focuses on staff functions.

Another consideration is that it is difficult to find training areas accessible for unit training that are large enough to train an entire brigade in doctrinally-sized maneuver areas. For echelons above brigade there are no local areas that permit doctrinally correct maneuver training. Thus, at brigade level and higher echelons, hybrid environments that link live, virtual, and constructive simulations become particularly important to meet training objectives, especially those concerning command, control, communication, computers and intelligence (C4I).

To ensure that formative development of the prototype decision aids included consideration of factors applicable to higher echelons, and to provide a broader framework in which to discuss the applications of hybrid simulations, the corps echelon was also examined.

Since CATS is not yet available for echelons above brigade, the study projected a training strategy from the Army Universal Task List for the corps echelon. Units selected for study are:

- Armor Battalion Task Force
- Mechanized Infantry Battalion Task Force
- Aviation Battalion (AH-64D)
- Artillery Battalion
- Forward Support Battalion
- Heavy Brigade Combat Team (Armor and Mechanized Infantry Task Forces, with support CS and CSS units)
- Corps Headquarters

These units, especially the Mechanized Infantry Battalion Task Force, provide a range of common task density and a diversity of specialized equipment and collective tasks that are likely to demonstrate the influences of change.

The next steps in determining the examples that were used to develop and test the decision aid was to select exercises appropriate to each of the echelons for the selected units. Then, to further narrow the range of applications for the developmental phase, particular functions were chosen for further examination from within each of the selected exercises. Finally, projected new combat systems were nominated for examination in the prototype development effort.

Selection of Exercises

Unit short range CATS describe training as a sequence of exercises built for identified training audiences and designed to train specific tasks. The training environments must be compared with respect to the degree to which they support training the tasks and functions in such exercises. Table 1-1 indicates which exercises were chosen for selected units and echelons. These exercises span the variety of exercises described in CATS. The STAFFEX was developed as part of the CATS to provide additional training exercises for the staffs. It is not yet a doctrinal term.

In order to further focus the efforts for this project, the supply company, which has a direct effect on the utilization of combat systems by the other units in the brigade combat team, was nominated for use in prototyping the application of the decision aids to units within the FSB. In addition, although there are echelons at brigade and above for other than armor and infantry (e.g., DIVARTY, DISCOM, COSCOM), the focus of the prototyping was on ground maneuver units at lower echelons, and a headquarters integrating and synchronizing combined arms and joint operations at an echelon above brigade.

Table 1-1

Exercises Selected for Comparison of Training Environments, by Unit Type and Echelon

	Individual	Squad/Crew	Platoon	Co/Tm/ Btry/Trp	Battalion/TF	Brigade Combat Team	Corps
Armor		TGT-VIII	FTX		FTX		
Mechanized Infantry (mounted & dismounted)	OICW & JAVELIN Qualification	BGT-VIII	STX QUAL	FTX STX	STAFFEX, CPX	STAFFEX CPX	STAFFEX CPX
Artillery		AT-VIII		CALFEX		CFX/FCX	CFX/FCX
Attack Helicopter		Table VIII	CFX/FCX	CFX/FCX	CFX/FCX		
FSB				FTX	FTX		

Moving up the echelons (from left to right on the chart), the functional emphasis shifts from engaging the enemy with direct fire at the individual and crew levels to functions associated with command and control at the higher levels. Table 1-2 shows the battlefield functions that were examined at each echelon.

Selection of Modernization Systems

To determine if the prototype decision aids capture the characteristics that help to distinguish among environments, the tasks selected as examples must represent a range over the echelon levels identified in Tables 1-1 and 1-2, and the functions addressed at each echelon. The new combat systems selected as examples must be likely to change the training requirements at particular echelons, so that the prototype decision aids may be applied to address the questions of best environment and best sequence in view of those changes.

Appendix C, Future Combat Systems and Equipment, provides a projection of technology trends, and a thumb nail description of sixty-nine future systems that will likely impact on decision making for Force XXI. The systems were selected from the current program operating memorandum (POM), the Army Modernization Plan (AMP) and from the Army Science and Technology Master Plan (ASTMP).[1]

[1] From the ASTMP 69 systems are identified as initiatives for future combat systems and upgrades to current combat systems. They are excellent candidates for a longer study on simulations.

Table 1-2

Functional Focus of Comparison, by Unit Type and Echelon

	Individual	Squad/Crew	Platoon	Co/Tm/ Battery/Troop	Battalion/TF	Brigade Combat Team	Corps
Armor		Engage enemy with fire	Engage enemy with fire and maneuver	Conduct Tactical Movement Direct and Lead Units in the Execution of the Battle Engage enemy with fire and maneuver	Plan for Combat Operations Direct and Lead Units During Preparation for the Battle Direct and lead units in the Execution of the Battle	Plan for Combat Operations Direct and Lead Units During Preparation for the Battle Direct and lead units in the Execution of the Battle	Plan for Combat Operations Direct and Lead Units During Preparation for the Battle Direct and lead units in the Execution of the Battle
Mechanized Infantry (Mounted and Dismounted)	Engage enemy with fire						
Artillery		Employ Field Artillery	Employ Field Artillery	Employ Field Artillery Direct and Lead Units in the Execution of the Battle Coordinate, Synchronize and Integrate Fire Support			
Attack Helicopter		Engage enemy with fire	Engage enemy with fire and maneuver Coordinate, Synchronize and Integrate Fire Support	Engage enemy with fire and maneuver Direct and Lead Units in the Execution of the Battle Coordinate, Synchronize and Integrate Fire Support			
FSB				Conduct Supply Operations Direct and Lead Units in the Execution of the Battle			

Table 1-3 shows some possible candidate systems arrayed by Army Tactical tasks (ARTs, selected from the Army Universal Task List, or AUTL), and identifies the eleven that were chosen for use in this project. These eleven systems represent short to long-term (2000- 2020) initiatives, span the key battlefield functions, and impact the units selected. They are considered highly likely to generate training requirements that will influence the choice of training environments. The eleven systems are:

- Objective Individual Weapon System (OICW)
- Javelin
- Bradley Fighting Vehicle Upgrade
- Abrams Man Battle Tank Upgrade
- Unmanned Aerial Vehicle (UAV) Hunter
- Crusader
- Apache AH-64 Longbow
- Raptor
- Combat Service Support Control System (CSSCS)
- Force Battle Command Brigade and Battalion (FBCB2)
- Bradley Line Backer

Table 1-3

Identification of Candidate Systems for Study

Brigade Combat Team Systems					
Maneuver ART 1	**Intelligence ART 2**	**Fire power ART 3**	**Logistics ART 4**	**Command & Control ART 5**	**Protect the Force ART 6**
M1A2 (SEP)*	UAVs*	JAVELIN*	CSSCS*	ABCS	Linebacker*
M2A3*	JSTARS	OICW*		MCS/P	DTSS
AH-64 Apache Longbow*	IEWCS	Crusader*		FBCB2*	Raptor*
Kiowa Warrior	GBCS	Paladin		A2C2S	FAADCCI
AH 64 Apache	AQF	AFATDS		AMPS	BCIS
	ASAS-RWS			ATCCS	CID
	IMETS			MPRS	CIS
				SINCGARS (SIP)	
				EPLRS	
				SDR	
				SIV	
				Tactical Internet	

* Systems selected for use in developing and testing ESELDA.

Overview of Remaining Chapters

The sections above have established the context for the development of the environment selection decision aid and the procedures for sequencing environments. The types of environments to be compared and sequenced have been identified; the types of units and the examples of new combat equipment to be considered have been selected; and general guidance for selecting missions, functions and tasks within the context of the CATS training paradigm

have been established. Chapter 2 describes the development of the environment selection decision aid. Chapter 3 describes the development of guidance and procedures for sequencing exercises and environments. Chapter 4 discusses future trends and capabilities in simulation environments. Chapter 5 summarizes the outcomes of the study and discusses some possible future projects/products that might complement and extend this work.

Chapter 2: Methodology to Select Appropriate Training Environments

The purpose of this chapter is to describe the development of a decision aid directed at determining the appropriate environment(s) in which to conduct training. The decision aid is intended for use in making general, high-level decisions about the appropriateness of training environments.

General Approach

There were five stages to the development of this decision aid:

1. Identification of four types of training environments that should be considered: Live, virtual, constructive, and hybrid.

2. Examination of the nature of collective tasks and development of general guidelines for mapping tasks onto training environments.

3. Identification of four broad characteristics that could be used to compare the environments: Feasibility, suitability, affordability, and deployability.

4. Development of the environment selection decision aid (ESELDA), based on the results of the prior stages.

5. Assessment of the face validity of ESELDA.

The types of training environments to be considered were discussed in the first chapter. The characteristics of the training environments to be considered were identified in the preliminary discussions with the sponsor concerning this project. These discussions revealed that they were concerned with being able to consider simultaneously:

- Suitability: The degree to which a particular function or task performed at a particular echelon could be trained in the environment.

- Affordability: The relative cost-effectiveness, or cost-efficiency, of training a particular function or task, at a particular echelon, in the environment.

- Feasibility: Whether all of the technologies needed to create the environment suitable for training the task or function at a particular echelon would be likely to be available in time and within budget constraints.

- Deployability: The degree to which the environment would impact deployment of units.

The sponsor also wanted to have a general discussion of the correspondence between the nature of functions and tasks and the types of environments in which they could be trained. The subsequent sections of this chapter summarize the primary considerations and findings resulting from the examination of these areas in greater detail, and review the development of ESELDA.

Relationship of Task Types to Training Environments

This section relates the nature of tasks to the selection of training environments. Because there is not much literature on the training requirements of collective tasks, the subsequent discussion of models relating the characteristics of tasks to instructional media is based on the literature about individual tasks. Finally, a notional application of training environments to tasks at different echelons is presented.

Very little research has been done relating training to the nature of collective tasks in the military. Kahan, Webb, Shavelson, and Stolzenberg (1985) identify two broad types of collective tasks based upon the nature of the interaction among the participants:

1. Coactive -- team performance is a combination of the performance of individuals, but not dependent upon their interacting to coordinate efforts. Kahan, et al. hypothesized that a rifle squad might be representative of a team performing this type of collective task. To the extent that Army collective tasks are coactive in nature, training could focus on the proficiency of individuals in their assigned tasks.

2. Interactive -- team performance involves interaction among the team members. The tank crew is an example of a team performing this type of task: The team's performance is dependent upon both the proficiency of the individuals at their jobs, as well as a high degree of interaction among the team members to coordinate their efforts. A battalion staff is another example of a team performing this type of task: All staff members are expected to contribute to the assessment of courses of action, arriving at a consensus recommendation. Army collective tasks of this nature require training of the collectives to attain and sustain proficiency.

Past research has shown that, for individuals, proficiency on motor tasks does not decay as rapidly as proficiency at procedural tasks (Adams, 1987; Army Training Board, 1985). Wisher, Sabol, and Ozkaptan, (1996) provide a contemporary application of these results to planning for training in operational units. Grimsley (1969) has demonstrated that low-fidelity trainers are well suited to sustaining individual proficiency at procedural tasks.

The User's Manual for Predicting Military Task Retention (Army Training Board, 1985), indicates that individual proficiency at very complex cognitive tasks (such as developing military plans) will decay rapidly. Proficiency decay among individuals may not be the major factor affecting unit proficiency, however. The mission training plan for the tank and mechanized infantry battalion task force (ARTEP 71-2-MTP, Department of the Army, 1988, p.1-4) states, "To determine the need for collective task retraining, the amount of personnel turnover is a key factor." Keesling and Ford (1997) and Keenan, Keesling and Graney (1996) provide evidence

that turnover has negative effects on proficiency. Broad general questions about the applicability of training media and the amount of training required to attain and sustain proficiency at interactive collective tasks have not been answered empirically.

The literature on selecting media to instruct individual tasks is voluminous and complex. Dynamics Research Corporation, asked to develop a flexible, automated media selection tool, described the current situation in this way (User's Guide to the Media Selection Tool, 1995, p.2-1):

> Media selection models abound in the ISD (Instructional Systems Design) literature. Which model is the best (is) the subject of much debate among instructional designers and researchers. . . . it is difficult to decide if there really is any model available today that is completely reliable and produces valid media recommendations.

One model (incorporated by Dynamics Research Corporation into their media selection tool) is the Automated Instructional Media Selection (AIMS) model due to Kribs, Simpson, and Mark (1983). AIMS is based upon a matrix that describes characteristics/requirements of tasks to be trained in one dimension, and media in the other. The cells at the intersection of rows and columns are weights describing the capability of the selected medium to support the task training requirement.

Some of the task training requirements considered in the AIMS model are: The type of learning (cognitive or psychomotor); the nature of the cues that should be presented (auditory, visual, etc.); the nature of the responses that should be permitted (voice, manual, etc.); the nature of evaluation permitted (immediate, self-evaluation, instructor evaluation, etc.); the level of learning (familiarity, performing a procedure, performing a job, etc.); and special needs (memorization load, crew/team interaction, etc.). While a wide variety of media are considered, most are applicable to individual training. In the fourteen years since AIMS was developed, constructive simulations for training groups (e.g., JANUS, BBS) have been developed, and considerable improvements in computer technology have made possible large-scale virtual simulations with complex battlefield scenarios (e.g., SIMNET, CCTT).

The information in the AIMS matrix was re-evaluated, updated, and condensed to generate the ratings of the overall match of environment types (live, virtual, constructive, hybrid) to types of learning shown in Table 2-1. Two broad types of learning are considered: Cognitive learning applies to those tasks that have a high level of cognitive processing, requiring the internalization of complex concepts and principles, and their application to solving battlefield problems. Psychomotor learning concerns tasks that require application of motor skills in response to cues that invoke either a procedural chain of behaviors, or a selection and tracking type of response. For each type of learning ratings are given for each environment with respect to cues, responses, evaluation procedures, and three different levels of learning.

Table 2-1

Matching Types of Learning to Training Environments

Type of Learning	Type of Environment: Constructive	Virtual	Live	Hybrid
Cognitive -- • **Information Processing** • **Decision Making**				
Cues	3	4	5	4
Responses	3	4	5	4
Evaluation	5	5	5	5
Train Procedure(s)	4	5	5	5
Train Job(s)	4	5	5	4
Train Mission(s)	4	4	4	4
Global rating:	23	27	29	26
Psychomotor -- • **Move** • **Shoot**				
Cues	2	5	5	N/A
Responses	1	5	5	N/A
Evaluation	5	5	5	N/A
Train Procedure(s)	2	5	5	N/A
Train Job(s)	2	5	5	N/A
Global rating:	12	25	25	N/A

Table entries are scale values: 0=No capability to train; 1=Very low capability; 2=Low capability; 3= Medium capability; 4=High capability; 5= Very high capability.

The evaluations of the hybrid environment were focused on cognitive tasks connected with directing and leading units. It was assumed that a command group from a relatively high echelon will be using this environment and that the training value of the hybrid environment is applicable to that command group. The training value to subordinate or attached units was presumed to be associated primarily with the environment in which they are training. The hybrid environment was given ratings for cues and responses that are higher than those for the constructive environment primarily because the addition of real units (in either virtual or live environments) will introduce friction of war factors that will increase the realism of the cues and responses beyond what is available through constructive models.

The rating given to the virtual environment for training missions was based upon the development of mission-level training support packages for echelons from platoon to brigade combat team in the Simulation-Based Multiechelon Training Program for Armor Units (SIMUTA, see Hoffman, Graves, Koger, Flynn and Sever, 1995). The rating given to the live environment for supporting training of psychomotor procedures was based on the presumption that practice in this environment will help to sustain proficiency.[1] Procedures within the cognitive type of learning are presumed to be associated with exchanging information and with

[1] If the procedures are not too complex, it may not be useful to develop separate procedural trainers; a constructive familiarization (e.g., wall-chart with lecture; computer-based instruction) might be followed by training on the real equipment (possibly assisted by embedded training systems).

steps in the decision making process. The live and virtual environments were seen as slightly more suitable than the constructive environment for training this type of procedure.

The information in Table 2-1 was combined with some general cost considerations and with general ideas about the nature of tasks performed at different echelons to produce a notional paradigm for employing training environments, shown in Table 2-2. The following paragraphs of this section discuss some of the considerations that led from Table 2-1 to Table 2-2.

Table 2-1 supports the notion that the constructive environment is not suitable for training psychomotor tasks, but is not very distant from the other environments in supporting the training of cognitive tasks. Note, however, that the constructive environment is very apt for familiarization training of all types of tasks. Thus, constructive training environments are a viable approach to providing training for new members of a command group, and for refreshment training for the entire group.

Generally, the degree of realism in a simulation determines its acquisition and operational costs. Thus, to train a given set of tasks, constructive environments should be less expensive than virtual environments, which should be less expensive than the live environment. The greater the realism, the more the training is expected to transfer to the real situation. On the other hand, it might be possible to do two or more repetitions in a virtual or constructive environment in the time required for one in a live environment; so there is a potential trade-off of realism for repetition. Furthermore, it is possible to train actions in a virtual or constructive environment that would involve unacceptable safety risks in a live environment; or would require too much costly support by other units.

In this project, the operational concept for hybrid environments was that the higher command group would be linked to a subordinate-unit event that would take place whether or not the higher command was involved. Thus, there would be limited additional operational costs for using the hybrid environment.

The cells of Table 2-2 show the preferred training environments for three general purposes: Learn, demonstrate proficiency, and sustain. All familiarization training should be done using the constructive environment (construed broadly to mean lectures, books, films, computer-based instruction, etc.).

Generally, the same environments are selected to train and sustain proficiency. Live training events that are used to train and sustain proficiency can be STXs, or FCX/CFXs, or CPXs -- the live equivalent of part-task trainers. The environments selected to demonstrate proficiency of echelons below division are high-cost qualifications (e.g., firing tables) or FTXs.

Table 2-2

Notional Application of Training Environments to Training Requirements at Different Echelons

Echelon:	Preferred Training Environment for: Psychomotor Procedures	Motor tasks (e.g., target tracking)	Cognitive components (rules, principles, decision making)
Individual	Learn: Low-fidelity virtual Demonstrate Proficiency: Live Qualification Sustain: Low-fidelity virtual/ Live	Learn: Mid-high fidelity virtual/ Live Demonstrate Proficiency: Live Qualification Sustain: Mid-high fidelity virtual/ Live	At this level cognitive components are subsumed in the other task types.
Crew/Squad	Learn: Low-fidelity virtual Demonstrate Proficiency: Live Qualification Sustain: Low-fidelity virtual/ Live	Learn: Mid-high fidelity virtual/ Live Demonstrate Proficiency: Live Qualification Sustain: Mid-high fidelity virtual/ Live	
Platoon	Learn: Low-fidelity virtual Demonstrate Proficiency: Live (Qualification/ FTX-EXEVAL) Sustain: Low-fidelity virtual/ Live	Learn: High fidelity virtual/ Live Demonstrate Proficiency: Live (Qualification/ FTX-EXEVAL) Sustain: High fidelity virtual/ Live	Learn: Constructive/ high-fidelity virtual/ Live Demonstrate Proficiency: Live FTX-EXEVAL Sustain: Constructive/ high-fidelity virtual/ Live
Company/Team	Learn: Low-fidelity virtual Demonstrate Proficiency: Live (FTX-EXEVAL/ CALFEX) Sustain: Low-fidelity virtual/ Live	Learn: High fidelity virtual/ Live Demonstrate Proficiency: Live (CALFEX/ FTX-EXEVAL) Sustain: High fidelity virtual/ Live	Learn: Constructive/ high-fidelity virtual/ Live Demonstrate Proficiency: Live FTX-EXEVAL Sustain: Constructive/ high-fidelity virtual/ Live
Battalion/ Task Force	Learn: Low-fidelity virtual Demonstrate Proficiency: Live (FTX-EXEVAL) Sustain: Low-fidelity virtual/ Live	Learn: High fidelity virtual/ Live Demonstrate Proficiency: Live (FTX-EXEVAL) Sustain: High fidelity virtual/ Live	Learn: Constructive/ high-fidelity virtual/ Live Demonstrate Proficiency: Live FTX-EXEVAL Sustain: Constructive/ high-fidelity virtual/ Live
Brigade Combat Team (BCT)	Training focus for BCT and higher echelons focuses on the commander and staff. At these levels there are no appreciable motor or psychomotor components requiring training. Periodically, the BCT will have the opportunity to participate in exercises at the CTC that can be used to demonstrate the degree to which training in other environments has transferred to actual proficiency.		Learn: Constructive/ hybrid Demonstrate Proficiency: Constructive (BCTP Warfighter); Live (CTC) Sustain: Constructive/ hybrid
Division			Learn: Constructive/ hybrid Demonstrate Proficiency: Constructive (BCTP Warfighter) Sustain: Constructive/ hybrid
Corps			Learn: Constructive/ hybrid Demonstrate Proficiency: Constructive (BCTP Warfighter) Sustain: Constructive/ hybrid
Joint Task Force			Learn: Constructive/ hybrid Demonstrate Proficiency: Constructive (BCTP Warfighter) Sustain: Constructive/ hybrid

Table notes: All familiarization training is done using constructive environments.
Low-fidelity virtual trainers are part-task trainers.
Mid-high fidelity virtual trainers for individuals and crews are equivalent to U-COFT, or higher fidelity.
High-fidelity virtual trainers for units above crew are equivalent to SIMNET, or higher fidelity.

The guidelines shown in Table 2-2 correspond in general features to the training paradigm proposed by Brown (1994) in which small units at home station do STXs in the live environment, followed by virtual simulations such as CCTT, then a validation (for the battalion or brigade level) in the live environment at the CTC, and a return to virtual (CCTT) at home station. High-fidelity virtual environments make it possible to build upon the lessons learned during the live proficiency demonstration and to train on tactics, techniques and procedures that would be too expensive or risky to train in the live environment (what Brown, 1994, calls "Ph.D tasks").

The paradigm presented in Table 2-2 also resembles the approach to training Army rotary-wing aviators described by Wightman, Adams, and Gainer, (1995). In their approach initial training occurs in simulators and part-task trainers, followed by validation in real aircraft, followed by training in a team/collective context (again in simulators and other devices), ending with graduation upon validation of skills in real aircraft. All of these approaches to training incorporate the notion that validation must be done in the highest-fidelity, whole-task, training environment. In general, for Army units the size of brigade combat teams, or smaller, the live environment currently meets these requirements.

Characteristics of Training Environments for Comparative Assessment

Four general characteristics of training environments were considered: Feasibility, suitability, affordability, and deployability. The goal of the project was to develop a way to assess the projected impact of a new combat system on each of these attributes and summarize the assessments to assist in identifying the appropriate training environments for that new combat system.

Because of the need to consider several characteristics of each training environment simultaneously, a multi-attribute utility model was selected as the framework for assessing the characteristics of training environments, and summarizing the assessments to determine the relative appropriateness of the training environments.

Table 2-3 presents an overview of the layout of the mechanical part of the decision aid. The various aspects of the characteristics of the environments are rows in the table. The column labeled "Weights" allows a different weight to be applied to each aspect to be rated. The training environments are represented by pairs of columns in the table. The first column for each environment (labeled "Rating") is the assessment of the aspect for that environment. The second column (labeled "WxR") is the product of the weight assigned to that aspect times the assessment. The sums of the weighted ratings are shown at the bottom and are used to compare the environments with respect to appropriateness for training.

Table 2-3

Overview of ESELDA Assessment Worksheet

Echelon:										
Exercise:		Training Environments								
ART:		Live		Virtual		Constructive		Hybrid		
Characteristics	Weights	Rating	WxR	Rating	WxR	Rating	WxR	Rating	WxR	
Feasibility										
(aspects)										
Suitability										
(aspects)										
Affordability										
(aspects)										
Deployment										
(aspects)										
Sum of weighted ratings:										

The approach taken in this project was to identify several aspects of each of the characteristics of training environments, each of which would be evaluated to indicate the appropriateness of the environment with respect to that characteristic. These aspects (sub-elements of a characteristic) were selected to be relatively independent (so that the same information would not be repeatedly entered into the assessment). Some of these aspects might be important enough to be considered go or no-go indicators for a particular environment. All of them have important consequences for the appropriateness of the environments.

Framing questions were generated to represent the aspects of each characteristic of the environment to be assessed. Appendix B contains the entire set of framing questions and the accompanying explanatory material. The remainder of this section briefly discusses each of the characteristics.

Feasibility

Feasibility asks whether there are any impediments to implementing a particular training environment. For example, certain resources might not be available (e.g., larger areas of training land), or a technical challenge might be too difficult in the time frame projected (e.g., realistic representations of a platoon of dismounted soldiers in a virtual environment), or there may be unacceptable risks associated with using the training environment (e.g., it interferes with commercial airspace). It is important to ask these questions early in the development of a training environment to determine whether further effort on that environment is warranted.

As a practical matter, feasibility must incorporate a reasonable cap on costs. Otherwise, it might be relatively easy to claim that the needed resources would be available, by assuming no cost constraints. If the projected costs to provide a particular environment are too high (e.g., costs to purchase new land, costs to field a simulator suite in which an entire battalion can be trained), that calls into question the further exploration of that environment. Any aspect of the training environment that seems likely to be "unavailable at any price" makes that environment infeasible. Any aspect of the training environment that seems "possible only at prohibitive cost" also makes that environment infeasible within the cost constraint.

Affordability

There are many approaches to the analysis of costs, cost effectiveness, and cost-benefits. Simpson (1995) concludes that the Department of Defense has not defined cost-effectiveness methods adequately. He feels that the cost aspects are relatively well defined, but the effectiveness analysis methods are not well developed. As the training environment becomes more clearly defined, the more precise cost analysis methods documented, for example, in DoD acquisition management policies and procedures (DoD, 1991) can be used.

Aspects of affordability identified in this project address costs in a way that should prove useful for assessing environments at early stages of development. Generally, costs can be categorized with respect to the life-cycle of the environment: Research and development, production and deployment, and operation and support.

Four additional cost-related factors that may influence the choice of training environments were also identified (it may be difficult to determine exact costs for these aspects of training environments):

- Relative efficiency. Some environments may be able to support training more events (one event = conduct a mission, task, or process, conduct the AAR, and reset for the next one) in the same time that one such event could be conducted in the live environment.

- Impact on legacy systems. Some environments may involve modification of an existing environment, or substitution of a new version of the environment for an old one. In either case, there will be consequences for using the modified environment to train legacy systems. For example, replacing the UCOFT with the AGTS will have consequences for summer training of Army National Guard units that have not received new tanks.

- Accommodation of future systems. This concern is more difficult to address precisely because the parameters of the future systems may not be clear. On the other hand, at least one example of a training environment is designed to provide wide flexibility in accommodating alternative equipment, possibly including some future systems (Aviation Reconfigurable Manned Simulator, or ARMS).

- Creation of hybrid systems. The Army is moving toward a Common Operating Environment (COE) and has established a Distributed Interactive Simulation (DIS) environment, and a High Level Architecture (HLA) for linking different environments. The proposed environments should be evaluated for their support of these initiatives.

Suitability

The suitability of the environment concerns the degree to which the functions and tasks may be trained within the environment. Suitability may be assessed by examining the effects on units trained through use of the environment, or it may be determined on the basis of judgements.

There are three ways to assess the suitability of an environment based on the performance of units that have been trained in that environment (Knapp, Ford and Hoffman, 1997). These methodologies are: transfer of training, performance improvement, and prediction. Transfer of training studies determine whether using the environment leads to comparable or better performance on the criterion tasks (compared to other training environments). Boldovici (1987) provides a review of this methodology, highlighting its strengths and discussing potential problems in implementation.

Performance improvement examines whether proficiency improves within the training environment itself. In a simulator such as COFT (Conduct of Fire Trainer), this would mean that repeated practice leads to greater proficiency (e.g., attaining higher levels of the training matrix).

Prediction examines whether attaining higher proficiency within the training environment is related to performance of the criterion tasks. Hagman and Smith (1996) show such a relationship between COFT proficiency and Tank Gunnery Table VIII. Such relationships do not, of themselves, prove that using the training environment improves performance -- they may simply reflect a common ability component.

The previous methods can only be applied once the environment is constructed and operational. Judgements of the degree to which the environment will support training the desired tasks may be applied at all stages of the development of the environment. The best illustration of this method is the Task Performance Support (TPS) Codes (SHERIKON, 1995).

In the present application, tasks were defined by the tactical level AUTL (Army Universal Task List) task areas, called ARTs (for ARmy Tactical). The aspects of suitability identified for inclusion in ESELDA were: Provision of appropriate cues, support for appropriate responses, incorporation of psychological stress factors, provision for feedback, and support for part-task training. Each of these aspects is discussed briefly in the following paragraphs.

Live environments will typically support some actions to a greater degree than will virtual environments. For example, in live environments soldiers would put up real camouflage, or dig real defensive positions. Virtual environments will typically not support those actions. (The capacity of the synthetic environment to depict the result of those actions -- show camouflage or

vehicles in defilade -- should be considered in rating the environment for providing appropriate cues.) For psychomotor and procedural tasks, it is very important that the environment provide the opportunity to carry out the actions. For cognitive tasks, it is important that the environment permit the selection of the appropriate response. Virtual environments will probably support procedural tasks and important psychomotor tasks. Constructive environments will not support psychomotor tasks, but for cognitive tasks (and some procedural tasks), such environments may be quite suitable.

Another aspect of performance involves the effects of stress. While simulated training environments are unlikely to create the same emotions as real combat (e.g., shock), they may incorporate various stress factors that will have psychological consequences (e.g., the real dangers associated with live fire; enemy surprises; rapid pace; continuous operations; complex operations). In some degree, the training given to soldiers and leaders is intended to enable them to function more effectively when they are under stress. Environments should be evaluated with respect to their ability to produce or manipulate such stress factors as danger/risk, pace, and complexity.

Feedback on performance is critical to improvement over time. Two types of feedback were examined: real-time and post-training. Real-time feedback can be intrinsic (the trainee observes changes in the synthetic environment related to his/her performance), or extrinsic (an agent not participating in the environment, e.g., a coach, comments on performance). Post-training feedback is extrinsic in nature -- the environment is no longer subject to manipulation by the participants. The capability of the environment to support different types of feedback should be evaluated.

One approach to instructional design is to partition tasks into components, then train the component parts prior to training the whole task. The different training environments may support part-task training to different degrees, and this may depend upon the approach taken to partition, and reassemble, the tasks. Naylor (1962) describes approaches to partitioning and reassembling tasks. A training environment might support one or more of the methods described by Naylor. The training developer has to decide whether the training environment will support the partitioning approach preferred for a particular task. Generally, the virtual and constructive environments are somewhat more flexible than the live environment in allowing partitioning.

Deployability

The ability to sustain forces for indefinite periods in regions that are not previously equipped to support training places a premium on the deployability of the training environment. Two aspects of deployability were considered for evaluation: The logistic burden of deploying the environment and the requirements for support of the environment, after deployment.

Testing the Face-Validity of the Decision Aid

The test focused on determining whether the framing questions were reasonable and had sufficient explanatory material (including the statements accompanying the assessment scale points) to guide the assessment process. The test included assessments of environments for training at echelons ranging from individual to corps, and covered a broad range of types of exercise. Table 2-4 provides the general framework for the test, and shows the result of the initial testing.

The rows of Table 2-4 show the echelons that were used for the trial runs, while the columns indicate the exercises that were used. At each appropriate intersection, the environments considered are indicated by letters: LF represents live-fire environment, F (for field) represents the live environment with simulated weapons firing and effects[2], V represents the virtual environment, C represents the constructive environment, and H represents hybrid environments.

The new combat equipment appropriate to each echelon was considered in making these assessments. Thus, the test runs for the brigade combat team and corps echelons consider all 11 systems to be operational. The company/team and battalion task force test runs consider only those systems organic to the type of unit. For platoons, the test runs consider only those systems organic to the type platoon. For crews or individuals, the test runs consider only the system operated by the individual or crew.

Table 2-4

Plan for Trial Runs of ESELDA

Echelon	Ind. Qual	Qual Table	CALFEX	STX	FTX	FCX/ CFX	CPX	STAFFEX
Individ.	**LF**,V							
Crew		**LF**,V						
Platoon		**LF**,V		F,**V**,C	F,**V**	F,**V**,C		
Co/Tm			LF, **V**	F,**V**,C	F,V,**H**	F,V,C,H		
Bn/TF					F,V,**H**	F,V,C,H	F,V,C,**H**	V,**C**
BCT					F,V,**H**	F,V,C,H	F,V,C,**H**	V,**C**
Corps							F,V,C,**H**	V,**C**

Environments considered are designated: LF = live fire; F = Field (live environment field exercise); V = Virtual; C = Constructive; H = Hybrid. ESELDA identified the environment shown in larger, bold-face type as the preferred environment in each cell -- however, some of the differences in overall ratings were small.

Constructive environments were not evaluated for individual, crew, or platoon qualification exercises on the grounds that these are heavily weighted to psycho-motor tasks that cannot be adequately taught in the constructive environment. Constructive environments might be used to familiarize soldiers with the nature of these exercises.

[2] The live environment versions of the CPX typically are not force-on-force type exercises.

Hybrid environments were considered only for connection to free-play exercises. Live-fire qualifications and tables, and the CALFEX, were considered too constrained by safety considerations to provide adequate input to higher level exercises. STXs were also viewed as too focused to provide adequate input to higher HQ. Similarly, some STAFFEXs have a very narrow training focus and should be run in isolation from other HQs.

Table 2-4 also provides a condensed summary of the results, highlighting the most appropriate environment in each cell by using large, bold type. Because the underlying differences are sometimes small, these results should not be taken as definitive. In particular, because the live environment was typically identified as the most suitable, but least affordable, giving additional weight to the suitability characteristic might result in the live environment being more appropriate in certain cases. This possibility was examined by doubling the suitability weights for evaluating environments for the armor platoon and the ground maneuver company/team. Under these conditions, the live environment (designated 'F') was preferred for the platoon STX and FTX, and for the company/team STX. This demonstration also illustrates the importance of the decision maker(s) input to assigning weights for each characteristic and aspect. Stakeholders in the decision need to review and concur with both the weights assigned to the characteristics and aspects, and the ratings of each environment with respect to these characteristics and aspects.

There may be circumstances in which the affordability characteristic should be given zero weight. The capability of the live environment to represent all METT-TC (mission, enemy, troops, terrain –time available and civilian considerations) conditions fully makes it the most suitable environment for conducting externally evaluated FTXs. These exercises must be conducted periodically under highly realistic circumstances in order to obtain unambiguous assessments of unit readiness.

Conclusion

The environment selection decision aid (ESELDA) was developed to provide a framework for assessing characteristics of training environments as they might be affected by the introduction of new combat systems. ESELDA provides for systematic assessment of various aspects of feasibility, suitability, affordability and deployability of environments with respect to the functions and tasks likely to be trained in a particular exercise for a particular echelon. ESELDA is intended to be useful at early stages of the procurement cycle, when the training environment (and possibly the combat system itself) is not fully specified. Additional discussion of ESELDA is found in Chapter 5.

Chapter 3: Methodology to Develop Suitable Training Sequences

The purpose of this phase of the project was to ascertain whether the information in ESELDA could be used to assist high-level decision makers to determine an appropriate sequence of training environments. The focus of this examination is on macro-level determinations of appropriate training sequences to sustain unit proficiency, rather than on the micro-perspective concerned with actually executing training as exemplified by the unit commander making decisions contingent on the his or her unit's training readiness under all the local constraints on facilities, time, and money.

Overall Approach

Several concerns influenced the development of the approach to the sequencing problem. First, it was noted that training programs are not typically built by sequencing training environments. Further, training is usually developed with a view to raise performance from a low level to the standard of excellence; the training sequence required to sustain proficiency may require extensive tailoring to suit each unit. Finally, the Army's Combined Arms Training Strategies (CATS) leave the sequencing of training exercises (and the appropriate environment) up to the unit commander. These concerns are developed briefly in the following paragraphs, then three generating questions are presented as a framework for considering the sequencing of environments.

Typically, training developers create sequences of training that build from part-tasks to whole tasks, or train enabling tasks prior to training the integrated performance of the tasks in the terminal learning objective. For each part-task or enabling task the developer selects the training medium (environment) that is most effective, usually within cost constraints. In some cases, it may make practical sense to use a single environment to train a sequence of sub-tasks, even though some of the sub-tasks in the chain might be better trained in an alternative environment. Thus, the typical training development process attends more to the sequence of tasks than the sequence of environments.

Once the skills are acquired, opportunities to practice the skills must be provided to prevent decay. Steps in lengthy or complex procedures are especially vulnerable to forgetting. In addition, personnel turnover will mean that untrained individuals continually replace personnel that have been through the training conducted previously. As a general problem, it may be possible to estimate the retraining needs of the typical unit, but it may not be possible to specify a training sequence that is uniformly applicable to each unit at any point in time, because of variations in turnover of key personnel.

The recently developed CATS (see Keenan, Keesling, and Graney, 1996 for further description) are directed at units in the mode of sustaining proficiency in the band of excellence. The CATS provide the rationale for determining how often (each year) such units will need to train specific tasks under current conditions, and they recommend a certain number of exercises of different types that can be used to meet these requirements. *However, the selection of exercise types, and the sequencing of the exercises (and thereby, the environments) is left up to the unit*

commander. The CATS do not propose a specific training sequence.[1] *Indeed, there is no Army doctrine that specifies a sequence of training events or environments that will sustain unit proficiency within the band of excellence.*

Although there is no doctrine to specify a sequence of training events or environments, three circumstances were identified in which it would be appropriate to examine or reconsider the sequence of environments:

1. The first circumstance occurs when new combat equipment or new TADSS are introduced. Such changes require that the applicability of the training environments be re-examined and may lead to a change in the preferences for certain environments, thus changing the sequence of training environments.

2. The second circumstance arises when decision makers at high levels wish to develop a training initiative aimed at solving a perceived problem within Army training. Such initiatives will likely entail re-examination of the training environments and sequencing.

3. Finally, high-level decision makers may wish to develop a notional training sequence for a given type of unit, perhaps as a benchmark to establish overall training resource needs.

Each of these circumstances is examined in the following sections.

<u>Sequence Modification Resulting from Changes in Combat Equipment or TADSS</u>

The approach to use when combat equipment or TADSS change is to start with the existing CATS and ask how the exercises in that strategy might be modified, given the nature of the change. The procedures are different, depending upon whether the change is to the combat equipment or the TADSS.

<u>New combat equipment</u>: Combat equipment should be broadly interpreted to mean any new weapon, C4I system, etc.[2] At the earliest stages of developing the new combat equipment, little will be known beyond the desired capabilities of the new equipment. The first step should be to examine the tasks that will be performed to determine which of the types of training

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[1] To demonstrate that it would be possible to conduct all of the events in the training strategy over the specified time interval (typically 18-21 months), a calendar of CATS training events was prepared for each battalion type for which a training strategy was prepared. Although these calendars reflect expert training developer judgment about sequencing events, they are not formally recommended training sequences.

[2] Changes to combat equipment are changes to the nature of the material with which units operate. Broadly speaking, one could imagine that a change to unit organization might have similar implications for re-examining the applicability of training environments. There would probably be concomitant changes in tasks that would require special attention in the suitability section of ESELDA. Changes in doctrine would primarily change tasks in ways requiring attention in the suitability section of ESELDA.

methods available (lecture, computer-based instruction, simulator, field exercise, etc.) should be used at various stages of training. Generally speaking, for collective training at crew level and above, the training opportunities consist of exercises recognized by the Army as useful to train these tasks.[3] Then, the environments that are appropriate for conducting these exercises should be reviewed. It could be very clear that the capabilities of the new equipment, if realized, would make certain environments unsuitable for training. For example, the introduction of hyper-velocity projectiles or missiles would increase the risk in using live-fire environments to participating soldiers and to the general public (because their range might make it easy for the projectiles to escape the boundaries of the training areas). If these risks become too high, they make the live-fire environment infeasible.

To make initial assessments of alternative environments the decision maker can use the relationship aid shown in Figure 1. The first two columns of boxes are referenced to the arrow at the left margin and show that there is a direct relationship between the cost and realism of training exercises.

The middle column shows that generally, it is preferable to train psychomotor tasks in a live or virtual environment, while cognitive tasks can be trained adequately in a constructive environment. The last two columns indicate that environments other than live typically are most suited to crawl and walk levels of training, although the hybrid environment can be used for run-level training of higher echelons.

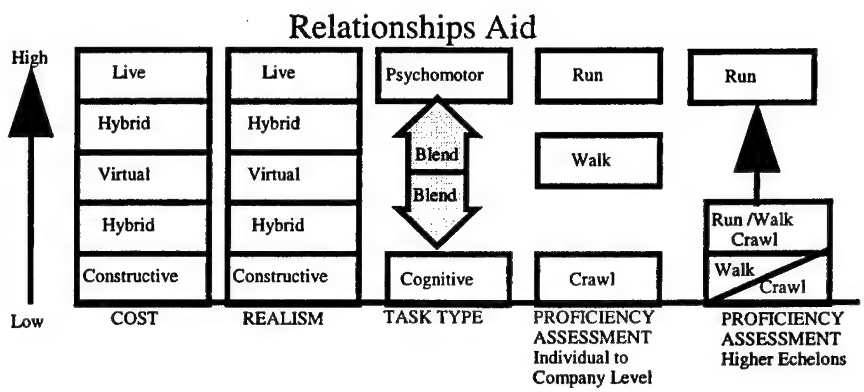

Figure 3-1. Relationships among cost, realism, task type, and assessed proficiency levels.

A more comprehensive analysis of the feasibility, suitability, affordability, and deployability of environments is available through the ESELDA process. Table 5 in Chapter 2 summarizes the outcomes of the trial runs conducted during the development of ESELDA. This information can be used to determine which environment would be most appropriate for conducting each exercise in the chosen sequence.

[3] In Battle Focused Training (FM 25-101), the Army provides a matrix (pages c4-c5) that links battlefield functions to appropriate training exercises. The authors believe that this matrix could be improved by: creating separate matrices for each type unit and echelon; substituting AUTL tasks for the functions; updating the list of exercises to reflect CATS guidance; and indicating whether the exercise was suitable for crawl, walk, or run training.

New TADSS: New TADSS should be broadly interpreted to mean any new training environment, new version of an existing environment, or new version of a specific item of TADSS used within an existing training environment.

To use ESELDA to assess the impact of the new TADSS on training environment sequences, the exercises (at all echelons) supported by the new TADSS would have to be identified. Then, ESELDA would be performed for each relevant combination of echelon and exercise to compare the alternative environments with those introduced by the new TADSS. The alternative environments should include the one being used for the current TADSS and other plausible alternatives, in addition to the one(s) influenced by the new TADSS. Feasibility and affordability criteria in ESELDA could be used to determine if any environment supported by the new TADSS becomes unworkable or too costly. If an environment supported by the new TADSS passes this test, then suitability and affordability criteria could be used to determine whether the new TADSS would be an appropriate substitute for existing environments.

At early stages of development of the new TADSS, the relationships in Figure 1 could be used to make these assessments, while at later stages the information needed to conduct an ESELDA analysis could be obtained and a more sophisticated analysis could be conducted.

Sequence Modifications Resulting from New Training Initiatives

Two types of training initiatives were considered: one addressed the issue of reducing training costs, the other directly addressed the issue of the environment in which to conduct specific training.

Cost-based training initiatives: The cost-based approach to modifying an existing training strategy, such as CATS, seeks to answer either of two questions:

- "What could be done to make the strategy more cost-efficient?"
- "What could be done to make the strategy more cost-effective?"

To make a training sequence more *cost-efficient*, less expensive training environments should be sought to replace those that are expensive. For example, certain exercises are expensive in terms of wear-and-tear on combat vehicles. Gunnery qualification is expensive in terms of both vehicle use and ammunition requirements. The starting point for the cost-based approach is to identify the expensive training means for a particular unit type and echelon. Then, ESELDA could be used to assess the whether there are feasible environments that are similar in suitability. Finally, the comparably suitable environments could be compared with respect to costs to determine whether changing environments would result in lower costs.

To make an overall training strategy more *cost-effective*, modifications to the training means should be sought that will produce more training benefit for the same use of resources. For example, when an exercise is conducted in a virtual environment (CCTT, e.g.), it is possible to program the simulation to include appropriate OPFOR elements (and simulate appropriate

lower-echelon friendly forces) without creating a large demand for additional personnel. Compared to the field versions of the exercise, which may vary in intensity and realism with the availability of personnel, the version in the virtual environment may enhance the training value of the exercise by providing consistent cues and permitting responses that correspond to critical training objectives.

To perform an ESELDA analysis of this innovation would require re-examination of the tasks to be trained in the context of this exercise. Specifically, the tasks for which training has been enhanced in one or more environments should be re-evaluated in all environments. This new evaluation may result in a preference for one of the environments in which the improvements have been effected. The costs of developing, operating, and maintaining the new version of the exercise must also be factored into this new ESELDA assessment.

Sequence-altering initiatives: Suppose that a decision maker wishes to alter the current training sequence. An alternative sequence is proposed and the goal is to make a comparative evaluation of the existing and alternative sequences.

For example, suppose that a question arises as to whether a particular element of officer training should be conducted in a TRADOC school, or in the units. It would be possible to develop two alternative approaches to training and compare their acceptability using the ESELDA methodology. The framing questions in ESELDA should be examined to be sure that the concerns that are paramount to both the institutional and unit training communities are well represented.

One might compare classroom training (institution-based) with unit officer development training with respect to required skills, knowledge, and attributes. This comparison could be accomplished using ESELDA, with suitable modification of the framing questions, by assuming that two environments (unit and institution) are being compared with respect to training the leader in the appropriate tasks.

Holistic Approaches

The holistic approach starts with a blank sheet of paper and, given information about the training requirements and training opportunities available, develops a strategy that provides guidance about frequency with which certain training means (combinations of exercise and environment) should be used, and may go so far as to specify a sequence of training events (and, thereby, a sequence of training environments). Two examples of this approach were examined: The first requires expert trainers to make judgments based on their background knowledge of the training requirements and opportunities; the second requires elaborating the relationships among training opportunities and training requirements in mathematical terms.

Expert judgment approach: Instructional development experts usually formulate a training strategy based upon an analysis of the tasks that must be trained. Task-based analysis is the basis for most guidance about training development for individuals. The media for training each task are ordered by suitability (by applying, for example, the Media Selection Tool

described by Dynamics Research Corporation, 1995). Then the expert groups tasks that should be taught together in light of the appropriate media, and their costs. The instructional development expert may elect to use a less-than-optimum medium for some tasks in order to preserve the continuity of instructional medium, or to reduce costs, or because the most appropriate medium is not available (e.g., no video production facility). The sequencing of instructional events is determined by the developer's assessment of the order in which tasks should be acquired. For example, simple road-marching formations are taught before the entire task of tactical movement.

A similar process could be employed to develop training sequences for collective tasks. ESELDA could assist in this process by providing information on the suitability and affordability of the training environments with respect to tasks for a specific echelon of a given unit. The more specifically the tasks and the environment are defined, the more accurate will be the information resulting from application of ESELDA. To provide suitability information at a high degree of task specificity, an analysis comparable to the task performance support code analysis for the Close Combat Tactical Trainer (SHERIKON, 1995) would have to be performed for each candidate environment. Once the training developer determines the clusters of tasks to be trained in a particular environment, then the operational costs of conducting the resulting training events in those environments could be determined. A method for amortizing the costs of developing and fielding the alternative environments would have to be determined to complete a cost/benefit analysis.

Generally, the task-based approach to individual instruction results in a one-time sequence of instruction leading to proficient performance. In developing instructional sequences for individuals, it is rare to consider which media should be used for sustaining proficiency or re-training. Typically, it is assumed that the individual will make sufficient use of the skills in his/her occupation to sustain adequate proficiency.[4] Retraining is, however, a particular concern for sustaining proficiency in collective tasks when there is personnel turnover in the unit. The sequence for initial training might not be applicable to sustainment training for a specific unit with its particular training needs and local constraints.

The task-based approach has been developed fully for eleven different battalion types[5], as described in the CATS (Keenan, Keesling, and Graney, 1996). A similar approach has been used to develop a strategy for brigade combat team headquarters. These strategies represent one way of organizing tasks at various echelons into "trainable clusters." The CATS propose a variety of means (combinations of exercises and environments) to use to train these clusters of tasks. They also provide guidance about how frequently task clusters should be retrained to sustain proficiency. CATS recognize some general constraints on costs and availability of resources by

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[4] Aviation is one clear exception: It is generally expected that flight crews will <u>not</u> routinely encounter many situations for which they need to sustain proficiency (e.g., dealing with various weather conditions or in-flight emergencies); consequently, high-fidelity simulators are used periodically to retrain these personnel in these procedures.

[5] Armor and mechanized infantry battalion task forces, artillery battalions (155 SP and multiple launch rocket system), attack helicopter battalion, assault helicopter battalion, air defense artillery battalions (Avenger and Heavy Division), cavalry squadron, forward support battalion, and engineer battalion.

indicating about how often certain high-cost exercises (e.g., FTXs) might be performed over a set period of time. For each battalion type involved in the CATS development a notional calendar was prepared to demonstrate that the repetitions of various exercises could be accomplished in the given time frame. This calendar also reflects expert training developer judgment about the sequencing of exercises that would be appropriate for a typical unit of that type.

At the battalion task force level, the CATS guidance generally resembles the guidance in Brown (1994): The live environment, which can pull together all aspects of task performance, is used to demonstrate proficiency, while virtual and constructive environments, which are typically tailored to more narrow training objectives, are preferred for the exercises used for initial learning and for sustainment.[6] The CATS can be seen as a task-based solution to the problem of sequencing exercises and environments, given the combat systems and TADSS available at the time they were developed. The CATS are descriptive, rather than prescriptive, in the sense that the unit commander must adapt them to his or her unit's needs and to local constraints on resources.

The methodology used to develop CATS is presented in detail in Keenan, Keesling, and Graney (1996). CATS is being integrated into the Standard Army Training System (SATS) and guidance addressed to unit commanders and training managers using CATS within SATS is currently under development.

The method discussed in the next section (on the linear programming approach) uses mathematical relationships to combine factors such as the typical rates of skill loss (through personnel turnover or forgetting), the costs of the training means (combinations of exercise and environment), the effectiveness of the training means, the desired level of proficiency, and the constraints on expenditures. By modeling all of these conditions simultaneously, it is possible to determine the frequency of repetition of training means and an appropriate sequence for their employment.

<u>Linear programming approach</u>: The linear programming approach addresses the overall problem of determining how many times a particular training means should be used in a given time frame. This number is a generic solution to the question of resources needed for training, but does not necessarily apply to any given unit at a particular time. With additional restrictions, this approach may also be used to indicate a sequence in which to use the training means.

The approach uses linear programming techniques to combine quantitative measures of initial proficiency, skill degradation over time, costs associated with each training means (exercise and environment), effectiveness of each training means, and resource availability to produce a hypothetical training strategy. One problem with this methodology is the lack of research permitting precise quantification of collective skill degradation as a function of personnel turnover and time without sustainment training. Another problem has to do with the

[6] Brown (1994) notes that virtual, constructive, or hybrid environments might also be used to provide training in tasks associated with missions that cannot be performed under the constraints of the live environment. Exercises built around such missions and tasks might be considered "graduate-level" training (performed after demonstrating proficiency in the live environment).

availability of cost data, and whether costs should include amortization of developmental expenditures as well as operational expenditures.

Murty, Djang, Butler and Laferriere (1995) examined the problem of determining the frequency with which events needed to be performed (within a 6-month time frame) to sustain a level of proficiency. They incorporated tasks at crew and platoon echelons. Their measure of skill degradation was based on subject matter expert assessments of the nature of the tasks and other work concerning the degradation of individual skill performance. They also used subject matter expert judgments concerning the effectiveness of each training means with respect to each of the tasks incorporated into their model.[7] The output of their trial analyses was a table showing the number of times each training device (environment) would be used in a six-month cycle of training for crews and platoons that would retain proficiency at the required standard while minimizing overall cost. The sequence of these activities is not an output of their analysis.

Matto and Moses (1997) addressed the dual problem of frequency and sequencing of exercises (over an 18 month time span). They focused on battalion-level tasks, and did not account for tasks needing training at platoon or company-team echelons. They used the data in CATS concerning the desired frequencies of task repetition as an estimate of the need to retrain. And they used the training means quality indicators in CATS as a guide to the effectiveness of the training exercise in sustaining or improving proficiency. The output of their trial analyses consisted of sequences of battalion-level exercises aimed at sustaining proficiency within the band of excellence, while minimizing costs. They also provided examples of training sequences when costs were not incorporated as a constraint, and the proficiency expected if limitations are imposed on use of certain training facilities.

Matto and Moses use input measures that are relatively easy to determine. In particular, they use the CATS to provide information about needs for sustainment training and effectiveness of training means. They also use both absolute cost data (actual dollars required to conduct a particular exercise) and relativistic data on resource requirement costs (costs of each training means are expressed in terms of percent of cost of a live-environment FTX, which was given the maximum value in their application). The absolute or relative cost of an exercise is a factor in determining which exercise to use in a particular sequence. Subject to overall cost constraints, the algorithm chooses a sequence of exercises that will sustain performance at a particular level of proficiency.

These features of the Matto and Moses model make it possible to use ESELDA results in projecting a training strategy appropriate for future mixes of combat systems. For example, the information on affordability in ESELDA might provide a basis for approximating relative costs associated with each environment. Table 3-1 lists some possible sources for data elements required by the linear programming approach.

Table 3-1

[7] A more formal task performance support code analysis would provide more precise data concerning suitability.

Input to Linear Programming Model

Input to Model	Data Element	Possible Sources
Initial Proficiency	Presumed level of proficiency of typical unit.	Typical QTB T/P/U assessments of unit proficiency.
Skill degradation	Presumed rate at which collective proficiency will deteriorate -- or, presumed frequency of retraining required to sustain proficiency.	CATS contain information on the frequency of retraining required to sustain proficiency.
Training Method Utility	The suitability of the exercise and environment for training each task/function.	CATS provides information in the form of quality ratings. Or, ESELDA assessments of suitability could be used.
Training Method Cost	The cost of the exercise and environment if used to train each task/function.	ESELDA assessments of affordability could be used. The decision maker must decide whether or not to include developmental costs. SATS has more detailed data on resource costs.
Resource Availability	Constraints on the availability of training resources.	Practical limitations on the frequency with which an exercise can be conducted. (For example, a range complex may be available to each company on a post for a total of 2 weeks each year, limiting the number of CALFEX exercises.) Overall cost constraints.

ESELDA was designed to compare environments for a particular type of exercise. The ESELDA results should not be used to compare types of exercise. Thus, the ESELDA information would be applied to choose among alternatives for a type of exercise. Or, ESELDA should be performed to evaluate all combinations of exercise and environment simultaneously. Again, it should be emphasized that the more accurate the definition of the future combat systems and their training requirements (at different echelons), and the more accurate the description of the alternative training environments, and their costs, the more reliable the results from ESELDA. Better data on the effects of personnel turnover and skill degradation on performance of collective tasks of different types at different echelons would also improve the validity of results from linear programming models.

Conclusion

Three broad contexts for making decisions about training sequences were examined. Each of the contexts resulted in a different approach to reaching a decision about which sequence of environments is most appropriate. For each of these approaches, an appropriate use of ESELDA assessments was presented. ESELDA assessments are based on global ratings of the generic environments. Such ratings are probably most valuable when the specific training requirements (detailed tasks performed by individuals and small teams) and the capabilities of a proposed training environment are at the initial stages of consideration. As more details become available, more precise cost and effectiveness analyses can be performed, and the sequence of environments can be adjusted to reflect the results.

Chapter 4: Future Trends and Capabilities

Background

The ideas and projections contained in this chapter are the opinions of the authors based on our view of the future. This view was formulated by reviewing numerous documents associated with simulation and training (included in bibliography) and from our experience.

The technologies for warfighting systems and computer-based simulators and simulations have been moving along two separate, but coordinated axes; they appear to converge at a point of operational capability for digital warfighting units between the years 2005 and 2010. For the period 2000 to 2010, the systems and simulations in the diagram below represent the core of training capability for the evolution of this force.

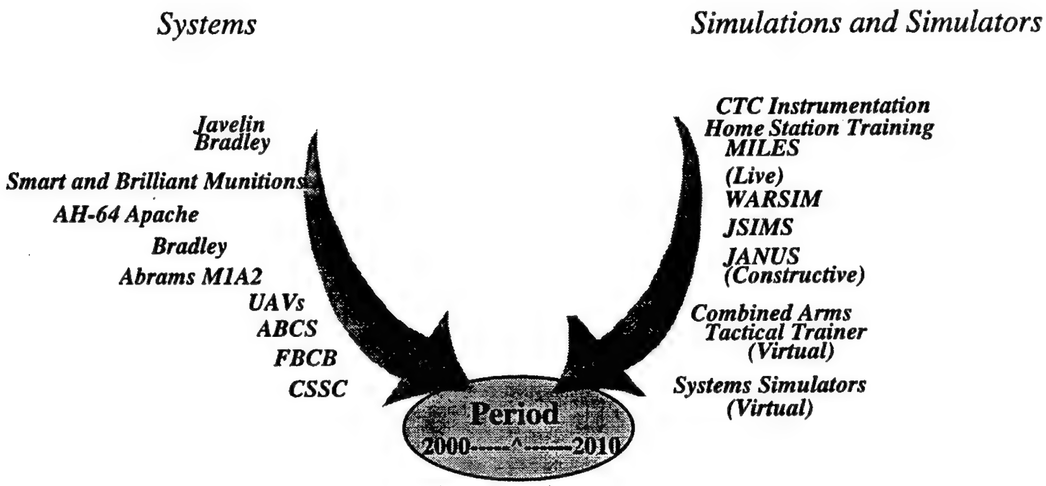

Figure 4-1. Emerging systems.

The systems on the left axis of the diagram and others that are likely additions to unit Tables of Organization and Equipment (TOE) for the same period are defined in Appendix C, Future Combat Systems and Equipment. As the acquisition cycle progresses for these systems, some will be eliminated, or the programs for development and fielding will be stretched out, while enhancements or reductions will alter other programs. Predictably, the principle combat power for the Army during the period 2000 to 2010 is expected to be the digitized force armed with a mix of old and new equipment. The Army's combat power will be exemplified by the M1A2 Systems Enhancement Program (SEP), M2A3, Apache Longbow, Crusader, Javelin, a family of Unmanned Aerial Vehicles (UAVs), greatly enhanced smart and brilliant munitions, and sensors. The Army will also have a world class, dynamic information management system that will provide real-time information about enemy and friendly forces. In addition, this information management system will provide or assist commanders with selectable, processed intelligence, exact target acquisition and tracking, fire and forget weapons and munitions, cognitive decision aids, mission rehearsal tools, and easy and precise navigation. (Petrosky, 1997) (Harmeyer, 1997)

The simulation training capability for the same period will consist of Joint Simulation System (JSIMS), Warfighters' Simulation (WARSIM) with intelligence module Tactical Simulation (TACSIM) or WARSIM Intelligence Module (WIM), Combined Arms Tactical Trainer (CATT), Synthetic Theater of War (STOW), Distributed Interactive Simulation (DIS), and simulators for the various systems. Other large simulation programs may emerge as a result of unforeseen advances in technology. However, for now, the economic situation, environmental concerns, and the political climate suggest that the more practical approach of building on the core of simulations currently under design and development, and a few of those currently fielded, will prevail.

Future Role of Simulation

The search for an optimum mix of simulations for use in training the force will continue to receive considerable attention and intense effort for three reasons: (1) competition for training funds, (2) opportunities made available by information technology advances, and (3) miniaturization technology.

First, the Army will have a much smaller force that must operate at a very high tempo with overwhelming firepower. The expected decreases in funding for training and operations coupled with the fielding of highly sophisticated and expensive-to-operate systems, will create difficult training and readiness challenges for this force. Simulation capabilities appear to answer these training challenges. The Army Posture Statement (APS) indicates that the Army understands the impact of simulations for the future and is formulating appropriate strategy and direction.

> The training challenges will be created by highly advanced weapons systems, higher tempo tactics for soldiers, and the pursuit of technology to improve precision, global positioning systems, high energy research, electromagnetic technology, and enhanced stand-off capability. Recognizing this impact on training and readiness the Army has established modeling and simulations as key technology for achieving the Army vision of 2010 and Army After Next.
>
> From individual and crew simulators through full blown field exercises at home and abroad, realistic evaluated training must remain our best combat multiplier. We are on an irreversible path for harnessing, leveraging, and embedding simulations across the full spectrum of key processors and equipment from the primary warfighters in high intensity combat units to the warfighter enablers in the indispensable combat support and combat service support units in the United States Army Reserves. (Army Posture Statement 99, 1997)

The second reason involves the high expansion rate of commercial computer and information technology that provide the tease of unlimited possibilities in portrayal of information in ways that approach realism. The performance of processors and capacity of memory chips has doubled every 18 months since 1970. This exponential growth is expected to continue until the year 2005. At that point, it is likely the cost of continued investment to build

new generations of chips with smaller transistors would provide an inadequate return on investment for the commercial industry. Up to the present, the vast improvements in military simulations are a direct result of leveraging commercial off-the-shelf technology and products. Without this leveraging, engineering and products development cost for training simulators would be prohibitive. After the year 2006, it may take multi-billion dollar investments to continue growth in memory chips unless there is an unforeseen technology breakthrough. This does not mean that a wall will come up, and that there will be no more improvement in simulations. Indeed, "state-of-the-art" simulations and simulators available to train the force will not have incorporated what will probably be the best available hardware or software because of the natural pauses in the development and procurement cycles. Such pauses (sometimes termed "good idea cut off times") permit product improvement in sort of a leap frogging fashion to take advantage of progressive, state-of-the-art technologies. Smaller and more powerful chips are very important, but they are not the only technology that will enhance the capability of simulations and simulators. Investing in other enabling technologies could lead to great improvements in simulation and training capability. Advances are required and expected in the following areas of technology to fulfill demands for increased use of simulation in the future.

- <u>High performance computing</u>: High performance computing encompasses conventional digital computer processing equipment, including microprocessors, vector processors, array processors and other computers, as well as, massively parallel and scaleable computing. All of these technologies are critical for battlefield digitization, human system interfaces, and the synthetic environment. High performance computing is also an enabling technology for processing the massive amounts of imagery and sensor data for real-time data fusion and generating synthetic environments for dynamic training and simulations, mission planning and rehearsal, and operational battle management. This technology will support improvements in live, virtual, and constructive simulations.

- <u>Human systems interface</u>: Human systems interface (man-machine interface) requires moving beyond the current use of joy sticks and key boards and into hands-off input devices with a resulting total immersion of the training audience into a virtual environment wherein normal actions are the input device, and the output from the virtual simulation is perceived as normal by the training audience. This is important to improve the perception of realism in simulators, and is particularly important for advancement with dismounted soldier simulations. This technology will support advancements in virtual simulations.

- <u>Software</u>: Software is, of course, the heart of the simulation and usually the most expensive part to develop and maintain. Improvements are expected in predictability, reliability, usability/reuse, error immunity, ease of use, and ease of production. This technology will support advancements in live, virtual, and constructive simulations.

- <u>Information system security</u>: While information systems technology can generate combat power, it also can be the Achilles heel of the force. It must be protected. Information security is not a problem in routine training, but can become critical for

mission rehearsal or practice of war plans. Information system security technology will support advancements in virtual and constructive simulations.

- Networks and switching: Networks and switching are the means to maintain continuity with all elements at all times, fixed or mobile. Simulations cannot become decentralized without this technology. Improvements in networking and switching technology are needed to support advancements in live, virtual, and constructive simulations, as well as hybrid mixtures of simulations.

- Intelligent systems: The objective is for the system/computer to autonomously adapt functionality in response to changing requirements and conditions without human operator intervention or pre-programmed logic constraints. This technology will support advancements in virtual and constructive simulations. It could also affect targetry in the live environment.

- Transmission systems: Transmission systems involve information transmission equipment and components used to transfer voice, data, graphics, and other information by electromagnetic means through cable. This technology will support advancements in live, virtual, and constructive simulations.

- Distributed Interactive Simulation (DIS): DIS is a synthetic environment comprised of disparate systems and r simulations within which humans can interact at multiple network sites using compatible architecture modeling protocols, standards and databases. Improvements in this technology are critical for linking live, virtual, and constructive simulations. This technology will support advancements in live, virtual, and constructive simulations.

- High Level Architecture (HLA): HLA is perhaps the key technology for progress in distributing simulations. It allows interoperability between models using the advantages of all simulation environments for training applications. HLA is a standard. It provides a framework for developing rules and for organizing concepts and protocols for the continued development of DIS. It will provide a common approach to the design, implementation, and execution of constructive, virtual, and live simulations. This technology will support advancements in virtual and constructive simulations.

The third reason for continuing the intense effort to field simulation tools for training is to capitalize on the number of opportunities created by miniaturization of communications, computers, data transfer devices and sensors. The uses of embedded computers within weapons systems and vehicles for mission rehearsal and training give promise of "on call" simulation training at any time, at any location. The technologies needed to support such embedding are: low cost, high power image generators, ultra wide band width, wireless Local Area Network (LAN), scenario generators, integration of virtual targets on system sensors and virtual target

effects. (Joint Warfighters Science and Technology Plan, 1997, JSIMS Concept of Operations, 1997 and ASTMP FY 97, 1997)

Embedded Training or Embedded Simulation

In the materiel development and training communities, the terms embedded training (ET) and embedded simulation (ES) are in vogue. In our opinion, ET and ES have great promise and should be exploited. There does appear to be movement toward embedding both training and simulation capability into unit equipment. ET enhances or maintains skill proficiency by allowing soldiers to train using their assigned equipment. ES is a simulation capability designed into major items of equipment or components which enables the system to provide cues necessary to train individuals, crews, and units. ES may also enhance or complement the equipment's operational capabilities by adding capabilities such as navigation or planning aids. The terms used to describe the types of ET and ES are defined in Table 4-1 below.

Table 4-1

Types of Embedding

Fully Embedded	**Appended**	**Umbilical**
All training or simulation functionality is built into the primary system.	The training or simulation system is attached to or installed in the primary system and removed when not needed. It may have permanently installed components such as sensors, connectors, power source, adapters, or mounting brackets.	The training or simulation system is attached to the prime system when needed and requires additional connections to external components (computers, instructor consoles, LANs, long haul digital circuits).

As indicated above, ET and ES are capabilities built into, added on, or connected to a major item of equipment or component. ET is further defined by four levels or categories shown in Table 4-2:

Table 4-2

Categories of Embedded Training

Category	A	B	C	D
Level	Individual/Operator.	Crew/Team.	Functional (interacting with people outside the system).	Force Level/Combined Arms (Interacting with people outside the system).
Purpose	Attain and sustain individual, maintenance, and systems orientation skills.	Train and sustain combat ready crews and teams.	Train and sustain functional area tasks for commanders, staffs and crew/teams within their operational roles.	Train and sustain combat ready commanders and battle staffs utilizing their operational systems in their operational role.

Category	A	B	C	D
ET Approach	Computer driven tutorial /courseware lessons	Computer driven crew courseware lessons /scenarios.	Computer driven simulation that present situations such as force-on-force exercises to practice using the primary system in collective training events.	External driven events for combined arms training such as linking to a virtual or constructive simulation to train as part of a task force or larger force.

The terms ET and ES are sometimes erroneously used interchangeably. In order to keep the terms in context, it is only necessary to understand that simulations and simulators are tools to facilitate training, and that training is the instruction and practice of performing tasks.

ES is a very promising area of technology and has the potential to greatly improve training capabilities. However, it has constraints and it is expensive. The advantages and disadvantages of ES are listed in Table 4-3 below:

Table 4-3

ES Advantages and Disadvantages

Advantages	**Disadvantages**
Training can be conducted without the scheduling and physical constraints of a centralized facility.	There will be increased logistics support associated with readiness of prime system and modifications to the training systems.
The means to train are available to the lower echelons of leaders at any level. This enables training requirements to be met quickly for those who are not proficient.	There will be addition wear and tear on prime system components.
Larger units can be linked in virtual and hybrid exercise events.	There will be added expense to harden/ruggedize ES components.
Mission rehearsals and after action review capabilities are enhanced.	During deployment, soldiers will not have access to their equipment to train.
Need for some part task trainers is reduced.	Simulators may still be needed to meet institutional training requirements.
Assist with skill decay problems.	
Provides on board, on call training and is deployable as unit equipment.	

Specific advantages and disadvantages may differ for each system. However, the general advantages and disadvantages are important to consider when developing an overarching policy and for decision making on embedding. An important question to be answered prior to implementing an overarching policy on ES is what should be embedded, in what systems, for what purposes. There should be a strategy beyond "embed everything possible". Without such a strategy, there could be a collage of embedded "stuff" which would not maximize training value added for the expense. There is a need to standardize the process of deciding what to embed. The

value added by embedding must always be worth the cost. General questions that should be addressed by such a policy are:

- What training support needs can be embedded? A partial answer to that question is evident now in requirements for virtual maps, digital terrain, tactical engagement systems, simulations for training flying, driving, or shooting, and computer generated forces, operating manuals, maintenance instructions and diagnostic tools, and equipment operating instructions.

- Should there be a standardized embedding approach for systems that work together in combat and training? Standardization in this area has the potential for long term cost savings in instrumentation, targets, and simulations.

- What is the true cost of a particular project? For example, simulation software is usually substantially more expensive than hardware.

- What will be the logistical impacts for a deployed force? For example, an important lesson learned from Desert Storm is that intense training will start almost immediately after arrival in a theater and will degrade the equipment readiness of the force if not carefully controlled. Training consumes batteries, sensors, filters, switches, circuit cards, electrical systems, wiring harnesses, tires, track, and so on.

(Department of the Army Policy an Guidance Letter, Subject: Embedded Training, 1987 and Draft HQ. TRADOC Pamphlet 350-70-xx, 1997)

Simulation Tools to Support Force XXI

There are over 2000 joint and Army models, simulations, and simulators currently available. Most are special purpose or analytic models and are not of value for training in units. This section summarizes by type the simulation tools that seem suitable for training and will probably be available to train Force XXI units in collective tasks. They are constructive simulations, virtual simulators, live-instrumented ranges, and enablers to link live, virtual, and constructive training events. Table 4-4 summarizes these categories of simulations and provides a brief definition of each. The subsequent paragraphs discuss these categories and contain tables for each category, which summarize the simulations that will probably be available between the years 2000 and 2010.

Table 4-4

Types of Simulation Environments

Live	Virtual	Constructive	Hybrid
Soldiers with their equipment operating on instrumented ranges or with feedback devices.	Manned simulators interacting within a synthetic environment.	Wargames and models that rely on rule sets or algorithmic and math methods.	Interactive combinations of live, virtual, or constructive simulations so forces can interact seamlessly.

(National Simulation Center, Training With Simulations: A Handbook for Commanders and Trainers, 1995)

Constructive Simulations

Constructive simulations are large-scale computer driven models used to train battalions, brigades, divisions, corps, and echelons above corps. In fact, at the division and higher levels, constructive simulations are the only simulation training tools now available. Traditionally, constructive simulations are used for training leaders and staffs in command and control functions. These simulations require considerable pre-event planning and employment of support personnel. For example, some of the best-known Joint Chiefs of Staff sponsored theater-level exercises require a year of effort by exercise planners to develop the plans to conduct a five-day training event. For corps and division exercises, the planning cycle is not as long, but the effort required to conduct a week long exercise is extensive and requires considerable personnel overhead for role players, Opposing Forces (OPFOR), simulation center experts, etc. The future represented by JSIMS and WARSIM promises to improve this situation by reducing personnel overhead requirements during exercises and by providing automated scenario generation capabilities. In addition, cognitive modeling techniques and computer generated forces technology will greatly increase the availability of these simulations for other echelons. Collective tasks could be practiced without the intense planning, coordination, and synchronization of peripheral response cells, opposing forces and the constraining involvement of other units to provide cues and stimuli. The constructive simulations expected to be available for the period 2000 to 2010 are in Table 4-5 (derived from information in JSIMS Concept of Operations, 1997).

Table 4-5

Constructive Simulations

Simulation	Training Audience	Description / Capability
Joint Simulation System (JISMS).	Leaders and Staffs. Joint Task Forces (JTFs), Unified Commands, Services/and Functional Components commands.	JSIMS will be a simulation that integrates unique Service simulations and provides the common core databases, software codes, and interfaces. JSIMS allows a means to practice war plans and command and control of the entire force (Army, Navy, Air Force, and Marine components) at all levels of war in all joint tasks.
Warfighter Simulation (WARSIM) and WARSIM Intelligence Model.	Leaders and Staffs. Battalion through Theater Level.	WARSIM will be the ground simulation for JSIMS, as well as, a stand-alone simulation to train Army units. It replaces BBS, CBS, CSSTSS, and TACSIM. WARSIM provides the enemy, terrain, weather, and scenarios for full range of warfighting events (mobilization, deployment, early entry operations, combat operations, OOTW, logistics, reconstitution, redeployment and demobilization) at tactical and operational levels of war. WARSIM will train command and control.
JANUS (up dated version).	Leaders. Battalion, Company, Platoon.	JANUS is a legacy simulation. It is an interactive event driven war gaming simulation which uses digitized terrain to train tactical doctrine and combat techniques.

While JSIMS, WARSIM, and JANUS should meet most of the training needs for constructive simulations, there is untapped training potential for constructive simulations in two

This type of thinking and planning should lead to holistic simulation support of unit training that automatically absorbs the new capabilities into the entire training system.

Table 4-6 describes the simulations that will support live training events during the period 2000 to 2010 (STRICOM Command Forecast, 1996).

Table 4-6

Live Training Devices and Simulations Anticipated for 2000-2010

Simulation	Training Audience	Description / Capability
Family of force-on-force training devices exemplified by MILES.	Entire units. All echelons up to Brigade Combat Team (BCT).	The force-on-force engagement training family of devices provides commanders and trainers with the means to conduct realistic combined arms and field training force-on-force engagement and exercises at any echelon. The Simulated Area Weapons Effects (SAWE)/MILES II devices simulate the effects of the Army's indirect fire weapons, plus area effects of enemy land mines, artillery fires, and nuclear, biological, and chemical (NBC) agents. The ability of these systems to accurately assess casualties provides units with a near real-time determination of their individual and unit fighting skills. MILES 2000 is a program to replace basic MILES devices at home station with state-of-the-art laser-based Tactical Engagement Simulation Systems (TESS). This system enables training at the tactical level of war.
Home Station Training Instrumentation (HTI) System.	Crews, and Platoon through Battalion Leaders. Battalion Task Force and below.	HTI will be a small mobile force-on-force range that can be set up at home stations. It supports force-on-force collective training and live fire with simulators. It will provide objective data collection of unit performance in live exercise events with an After Action Review (AAR) system. It is modular and will provide the unit being trained the information capabilities (situational awareness) that would be available from real world command, control, communications, computers and intelligence (C4I) systems. Supports training of tactical, individual and collective tasks.
Combat Training Center Upgrades. National Training Center (NTC). Joint Readiness Training Center (JRTC). Combat Maneuver Training Center (CMTC).	All levels of the entire brigade combat team. Battalion Task Force/ Brigade Combat Team.	The CTCs are the Army's best force-on-force facilities. Continuous upgrades are expected in order to replicate the impact of the digital force and new weapons systems. CTCs support training individual and collective tasks in force-on-force and live fire events. Key components of the CTC system include TESS, functionality of equipment, Range Data Management Systems (RDMS), collection and transmission of event data, Range Management Communications Systems (RMCS), automated integration of communications other than event data, Threat Emitters and Sensors (TES), simulations of effects of threat systems, and AARs.

Virtual Simulation

Virtual simulations are used to train individual soldiers, crews, and small units in collective tasks. Currently these simulations are simulators that replicate actual unit equipment in functionality. People and equipment can interact with a synthetic environment and other simulators through the use of computers or image generators. The future trend will be to embed into the actual system the simulations and/or connections for receiving distributed data from a central core database. The core database may contain a common battlespace including terrain and computer generated forces. DIS and LAN systems will be used to interlock other systems, simulators, and simulations for a large variety of exercise events and scenarios. The hierarchy of high, medium and low fidelity virtual simulators will continue to play an important role in the Army's training strategies for part or full task training. The important issues to be addressed for virtual simulations are:

- What parts (terrain, semiautomated forces, etc.) of the simulation should be embedded?
- What are the right mixes of simulators by type?
- How much realism and fidelity are enough for learning transfer?

Table 4-7 describes the simulators that will be available to support collective training for the virtual environment.

Table 4-7

Non Systems Simulators

Simulator	Training Audience	Description/Capability
Aviation Reconfigurable Manned Simulators (ARMS).	Crew members, crews, and company leaders.	ARMS is a National Guard reconfigurable simulation that supports training in six types of rotary winged aircraft (AH64A, AH1, OH58D, UH1, UH60, CH47D). It provides a practical means to practice collective tasks with an interactive enemy. It is interoperative with Close Combat Tactical Trainer (CCTT) and links to constructive simulations via the units' command and control (C2) systems.
Combined Arms Tactical Trainer (CATT).	Crew members, crews, company level leaders, battalion commanders and some staffs.	CATT is a collective training system composed of CCTT, Fire Support Combined Arms Tactical Trainer (FSCATT), Aviation Combined Arms Tactical Trainer (AVCATT), Air Defense Combined Arms Tactical Trainer (ADCATT), and Engineer Combined Arms Tactical Trainer (ENCATT). CATT supports training of tactical collective tasks.
Close Combat Tactical Trainer (CCTT).	Crew members, crews, company leaders, battalion commanders and some staff members.	CCTT is a system of computer driven combat vehicle simulators (M1A1/2, M2/3A1, M113, Fire Support Team Vehicle (FIST-V), and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) and emulators which work interactively. The systems computer creates a synthetic battlefield with the elements and conditions that would be encountered in combat: weather, enemy, terrain, smoke, fog, day/night, motion, noises. It uses SAF to replicate enemy and other friendly forces. This system supports collective training at the tactical level of war. This is the building block for the larger CATT simulation.

As previously indicated, system simulations and simulators are primarily focused on the tasks (individual and crew) concerned with operations, maintenance, and employment of the weapons and other systems on platforms. Most of the existing simulators support weapons, combat mechanized equipment, and combat aircraft. As a matter of policy, this type of simulator is usually developed and fielded in parallel to the actual system.

Examples of systems simulators are provided below (Table 4-8). (STRICOM Command Forecast, 1996)

Table 4-8

System Simulators

Simulator	Training Audience	Description/Capability
System Simulators.	Individuals, crew members, and crews.	Examples are: Conduct of Fire Trainers, Flight Simulators, Tank Driver Trainer, Through Sight Video, Engagement Skills Trainer, Advanced Gunnery Training System, Crew Stations, TWGSS, Guard Fist, PGTS. Supports individual and crew task at the tactical level.

Hybrid

The technologies in Table 4-9 make possible the linkage of the three environments (live, virtual and constructive) which creates a hybrid environment and makes realistic exercise events possible without physical presence in any particular location. These technologies and their enabling technologies collectively hold the key to training the total force in collective tasks at all echelons and levels. These technologies will not only allow a menu of training strategies for brigade and below, but will provide the capability to build a division, corps, or theater Virtual Training Center. (STRICOM Command Forecast, 1996)

Table 4-9

Supporting Technologies for Hybrid Training Environments

Simulation Enablers	Training Audience	Description/Capability
Distributed Interactive Simulation (DIS).	All levels and echelons.	DIS is the technology that allows the linking simulators and simulations representing a diverse set of weapons systems and units. It communicates over local area, wide band, and long haul networks. Linked nodes are able to operate within a shared synthetic environment. This technology enables multi-echelon, joint and combined arms training of large and small units and experience common outcomes from battle events.
Common Technical Framework (CTF) .	N/A.	The CTF includes the Higher Level Architecture (HLA), Conceptual Models of Mission Space (CMMS) and Data Engineering and Standards. The CTF facilitates the development of cost effective models, interoperable and reusable models, and simulations.

Simulation Enablers	Training Audience	Description/Capability
Synthetic Theater Of War (STOW).	All levels and echelons.	It is a congruent battlespace or environment created by linking virtual, live, or constructive simulations. STOW is a powerful tool for training large multi-functional/echelon units.
One Semi-Automated Forces (ONESAF).	All levels and echelons.	A composable next generation computer generated forces (CFG) that can represent a full range of operations, systems, and control process from individual up to battalion level, with variable levels of fidelity with human in the loop for round out of friendly forces. It can support an exercise scenario for brigade level friendly forces and will link with other simulations to support exercises higher than brigade. It will accurately represent engagements and maneuver, C4I and combat support and combat service support. For enemy forces it provides a capability from individual up to division level.

A Summary of Projected Simulation and Simulator Capability

The simulations, simulators, and supporting products discussed above represent the state-of–the art. The following list is a projection of the expected improvements in capability they collectively represent (Oyler, 1997):

- Distributed interaction of live, virtual, and constructive simulations and simulators.
- Automated connectivity to computer based instruction (CBI) systems.
- Integration of live, virtual, and constructive simulations and simulators to support high fidelity mission rehearsal and analysis tools.
- Capability of simulating or portraying operations other than war with constructive exercise events.
- A great reduction in the overhead required supporting an exercise-training event.
- International interpretability of constructive and virtual exercises events via HLA.
- Modular modes for constructive simulations including part task training and single unit stand-alone events.
- Scenario generation capability by the user.
- On call computer generated forces with doctrinally correct actions and reactions.
- Accommodation of different scales of simulations interaction.
- Rapid after action review capability.
- Simulation time controllable by user.
- Dynamic synthetic, three-dimensional environments.
- Voice and speech recognition and speech synthesis.
- Digital terrain mapping.
- Very small, high fidelity flat panel displays.
- Databases that are inexpensive to produce and maintain.
- Three dimensional virtual reality displays of constructive models.
- Greater visual realism.
- Lower life cycle cost.
- Dismounted Infantry actions integrated into simulators using “gesturing” technology.

Far Term

It is difficult to predict the future beyond 2010. Indications are that emerging technology will allow the creation of a joint, Virtual Training Center, and enhanced, robust home station instrumented ranges (virtual OPFOR, linked to live fire, other force-on-force ranges and other simulations and simulators). JSIMS and WARSIM should reach full operational capability; the live combat training centers should be updated with high-fidelity instrumentation systems; technology for embedding may lead to a brigade level CCTT; and unit C4I equipment will likely routinely be used as the input output devices for simulations. The concept of a brigade CCTT and joint Virtual Training Center are addressed in the next section.

The Challenge for Training Future Collective Tasks

Review of the Army Universal Task List, the ongoing work to define digital tasks to update the CATT, and published articles and manuals on Force XXI indicate that there does not yet appear to be an extensive list of new collective tasks resulting from digitization. However, digitization of the force does provide the means to accomplish missions faster with significantly less planning time, greater dispersion of units, and limited voice and face-to-face communication. Perhaps the greatest training challenge for Force XXI will be leaders' use of and trust in the electronic data available to them to synchronize the simultaneous employment of all forces employed in nonlinear operations in a multidimensional battlespace at a high tempo. It will be a challenge to train commanders and their staffs to learn to use the power of this new capability to plan, rehearse, and execute battlefield operations.

Practicing the full range of collective tasks associated with conducting operations on a multidimensional nonlinear battlefield to achieve the concepts of simultaneity, integration, and precision employment of forces and weapons, will be difficult. However, to be successful on this battlefield, commanders of large land forces must develop a sense of the battlespace, logistics, and the time it takes to position forces, conduct strikes, refuel, rearm, etc. The only way to practice this routinely on a large scale will be by using a combination of live, virtual, and constructive simulations simultaneously.

Improved situational awareness and battlefield vision, greater dispersion, sensors linked directly to shooters, high tempo operations, greater ranges of weapons and sights and other technologies are conditions that will require great understanding of the "big picture" at the small unit level. This understanding will be the key in a combined arms operation for successful synchronization, coordination, and integration of the full combat power of a digitized force. Leadership training for crew chiefs/squad leaders and practice in understanding and executing the commanders' intent two levels up should also receive a high training priority. Another training challenge for focus at all levels will be continuing operations when the systems are down or are operating intermittently and when digitized units are mixed with non-digitized units. The means to achieve and retain proficiency for these Force XXI challenges is scaled, repeatable training events, which are best done by simulation.

For Force XXI, the principles of maneuver and support will remain basically the same. Again, the major change is expected to come with the information tools that will allow execution of rapid, continuous operations at a very high tempo. At the battalion and higher levels, the synchronization and integration of the battlefield operating systems will remain the fundamental objective of training. The automated tools of digitization will enhance their command and control functions by providing a common relevant picture of the battlefield through real-time sharing of friendly and enemy battlefield information. An expected training challenge with this capability will be teaching commanders and staffs to achieve situational awareness and exploit it by immediate action. At the individual and crew levels, soldiers will have to do things differently and learn skills associated with the new capabilities (use digitized maps, navigate with the Global Positioning System (GPS), react to sensor data, etc.). However in the final analysis, they will still shoot, move, maintain, and communicate.

One possible way to optimize the future training capability and meet the training challenges of the multidimensional, nonlinear battlefield of the future is to integrate the various simulation capabilities into a single system. This system would use the power of information technology and build on the current capabilities of the Battle Command Training Program (BCTP) and the maneuver CTCs (NTC, CMTC, and JRTC) and broaden their linkage in support of home station training. Such an approach would provide the means to seamlessly combine or link training events for units at different locations from the national level to the tactical level into a meaningful training cycle.

Currently, the maneuver CTCs represent the best of our live training capability for brigades and battalions while BCTP is used to train C2 for division and corps level commanders and staffs. The maneuver CTCs have been described by senior leaders as national treasures which are critically important to national defense. They are essentially the graduate school for brigade and battalion operations and the only place where most of a brigade's assets can be employed in a live force-on-force simulation. Upgrades to the CTCs should continue to be a high priority to train the analog and digitized brigades. While the CTCs will probably remain as the premiere training opportunities for brigades, they are not enough to meet the training challenges of the total force.

In the future, as now, most of the training of units will be accomplished at home station. If the Army were to deploy to war tomorrow only two or three brigades would have "recent CTC experience," but all would have had recent home station training experience. This situation will not change in the future. Therefore, the fielding of the Home Station Training Instrumentation seems equally important as CTC upgrades.

It is time to consider expanding the Army's capability to train. Future battle with small offense oriented forces operating deep in the enemy's territory will likely rely on coordination, synchronization, and precise employment of long-range precision fires delivered by air, land and maritime forces. Live fire training of future weapons systems will be of a nature that home station ranges cannot support. The CTCs' and home station training experiences could be greatly enhanced or supplemented with a Virtual Training Center and a Joint Live Fire Center. A Virtual Training Center of some type would function as a core and distributing link for resource and

simulation fungibles such as computing power, SAF, OPFOR, software, terrain, databases, information and communication systems, targets, emulators, and interface tools. A Joint Live Fire Center of some sort would be available to validate proficiency and practice the tasks and processes of coordination and synchronization of precision strike and simultaneity required for fighting in a nonlinear, multidimensional battlespace. A Joint Live Fire Center could support such requirements that are not supported at current training facilities.

The important advantages of the CTCs are maneuver space, live fire ranges, instrumented force-on-force maneuver areas, OPFOR, a play-back AAR system, and observer controllers. These same advantages could be emulated at dispersed home stations by using a combination of live force-on-force instrumented ranges (e.g., HTI), virtual simulators (e.g., CATT) and constructive simulations (e.g., WARSIM) in a STOW. This system could be linked to other installations. The Virtual Training Center could provide controllers, a play-back AAR system, SAF and an OPFOR. Some of this concept is resident or under development at the National Simulation Center at Fort Leavenworth and other simulations centers. Figure 2 illustrates this concept of seamless interoperability between large-scale constructive, virtual and live training events.[1]

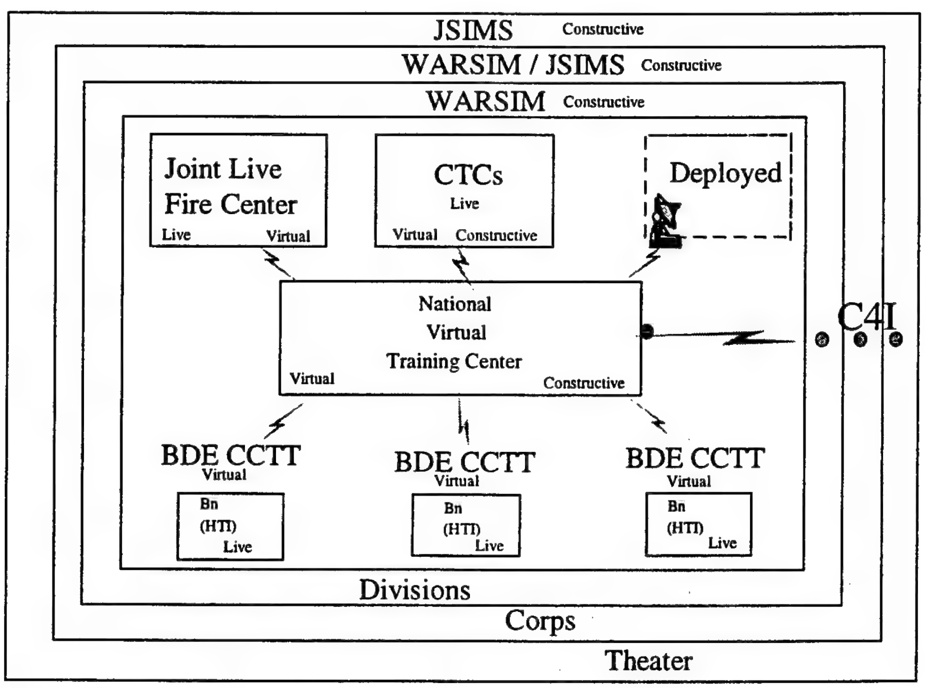

Figure 4-2. Concept of seamless interoperability.

[1] Flexibility is the power of this concept. The total force (Active Component [AC] and Reserve Component [RC]) can be trained collectively as a team in the full range of its functions. The constraints of distance and time are not an issue for dispersed units (many units are not now collocated with their parent headquarters). The unit commanders could select and schedule required and unique events or participate in larger events within the same simulation system. The concept supports training for small elements operating deep and employing long-range joint fires and national assets. Small and large-scale exercises can be conducted with traceable impacts on logistics systems so that realistic planning and programming of war reserves could be based on the actual experience of all echelons from the lowest to highest levels.

In this concept, WARSIM and JSIMS represent the constructive environment, CATT represents the virtual environment, and instrumented ranges and targets represent the live environment. This sort of seamless interoperability would make possible large-scale linking of training and mission rehearsal for dispersed units. The linkage would be achieved by using unit C4I equipment, augmented as needed with communication simulators. The concept assumes that JSIMS, WARSIM, and HTI programs achieve full operational capability and that a brigade level CCTT will be developed by either embedding simulations or by building more simulators. The Virtual Training Center (centralized or decentralized) would function as a simulation core and distributing center for any portions of the simulations that are common (terrain, enemy, friendly forces, databases, software, interface systems, emulators, etc.). The Joint Live Fire Center would enable live training for commanders, staffs and units of Army and joint tasks required to synchronize maneuver and fires in the future.

Conclusion

The future force will train in a way different from today's Army. The information and weapons systems being developed for Force XXI and the Army After Next should cause a change in the training events used to obtain and maintain proficiency. The traditional field training exercise may no longer be the best culminating event for a sequence of collective training. With new weapons systems and the greatly increased capabilities of the digitized force, the capacity of training facilities, especially at home station, may be so insufficient that only parts of the tasks required for proficiency can be trained in a live environment. Live events may be too expensive to provide the repetitions needed for learning transfer. Linked live, virtual, and constructive training may be the best way to gain and maintain necessary proficiency.

The foregoing discussion is presented as a window into the future capabilities and training use of simulations. It is meant to stimulate thinking about the use of simulation to support training in the future. It also provides a background of information about the future that can be used to develop and explore new ideas. Study of numerous documents on training and simulation and the experience of the authors formulated the ideas and concepts presented. It is recognized that leap-ahead technology resulting in new weapons and simulations and unforeseen advancements in information technology can greatly alter the above assessment. However, it is safe to predict that at the minimum, future simulations will present significant improvements in the areas of exercise control, distribution, realism, fidelity, and repeatability.

Chapter 5: Discussion and Recommendations

The development of ESELDA, the decision aid to assist in the identification of the most appropriate training environment for a particular task or function, focused on Army tactical tasks (ART-level of the AUTL) and collective training exercises. The decision aid appeared to lead to reasonable recommendations when tested by examining the likely impact of new combat equipment on a variety of Army unit types. Subsequently, it was demonstrated that the information developed through the use of ESELDA could be used to guide the modification of an existing training sequence, or to develop a new sequence. These tools should prove to be useful to training managers and developers. Although the test examples were focused on training for mid-intensity conflict, these procedures appear to be equally suited for assessing and sequencing training environments for use in preparing for operations other than war. This chapter provides additional comments about the structure and use of ESELDA, both for selecting and for sequencing training environments.

Because of the requirement that ESELDA systematically consider multiple aspects of feasibility, suitability, affordability, and deployability, a formal decision-model was proposed. The formal structure of ESELDA, and the considerable amount of guidance provided for each aspect to be rated should not be regarded as constraints. The framing questions may be modified, deleted, or replaced, as necessary. The statements accompanying the levels of each assessment scale may also be revised. Such modifications should be used to tailor ESELDA to focus on issues of greatest importance. The earliest stage of using ESELDA should be to agree on the nature of the framing questions and the meaning of the ratings.

At the earliest stages of development, when solid information about the system and the different training environments is less likely to be available, it might be useful to use yes/no ratings, rather than ratings on a scale. It may be important to establish a rating scale, but use it in a yes/no mode early in the process of reviewing potential training methods. One way to accomplish this would be to consider scale values of zero or one to be equivalent to "no," while values of two or above would be considered to equate to "yes."

ESELDA should not be looked to for permanent, "definitive" answers. Changes in combat systems through their development cycle, or changes in the capabilities of simulations (or in the resources to support their development and deployment) will surely frustrate such expectations. Generally, the best use of the ESELDA will be as a point of departure for discussion of the assessments, to identify aspects of the environments that may need particular attention (those receiving low ratings), and to facilitate consensus-building among trainers, training developers, and system developers about the environments to employ in training soldiers to use the new system. The process of framing the issues and developing the relevant information should have the effects of making the decision making process clearer, and building support for the decisions that are made.

The development of training sequences depends crucially on estimates of the rate at which unit proficiency deteriorates, as well as the relative costs and effectiveness of the training

means (combinations of exercises and environments). The suitability and affordability assessments in ESELDA could be used to compare the relative costs and suitability of training means. This information is also very useful in determining how to modify existing training sequences to account for new combat equipment, new TADSS, or to make training less costly.

There is little quantitative information about the rate at which collective task proficiency declines. Decay of skilled performance by individuals has been extensively studied and documented, but little has been done to assess the rate at which collective skills degrade in the absence of training. The information about individual skills is important, but does not address the effects of personnel turnover on collective performance. Decisions about sequencing training (e.g., the frequency with which training must be repeated to sustain performance within the band of excellence) would be on much firmer ground if quantitative information about collective skill decline could be made available.

Several recommendations can be made for the future direction and expansion of the work summarized in this report. The most obvious would be to examine additional unit types and more examples of future combat equipment. This project only examined five of the eleven unit types for which CATS were developed. And, it considered only 11 of 69 new or upgraded combat systems identified in Army planning documents. These additional unit types and systems might help to identify additional aspects of feasibility, suitability, affordability, and deployability for inclusion in the ESELDA prototype.

The ESELDA prototype focused on evaluating the different environments with respect to exercises that were developed for training relatively high-order collective functions and tasks (the ART-level of the AUTL). It might prove interesting to focus on more specific tasks for selected units (defining the tasks either by moving to lower levels within the AUTL tasks, or by using ARTEP-MTP tasks for the echelons of the selected units), and attempt to determine whether the new combat systems would cause changes in these more specific tasks. Then, the effect of these changes would be examined with respect to the environments in which the tasks are trained. The TPS Code methodology, or ESELDA, could be used to examine the suitability of the environments for training the altered tasks. ESELDA could be used to examine deployability, affordability and feasibility issues. Since there are a wide variety of tasks at different echelons that might be impacted, it would be appropriate to conduct a preliminary investigation limited to one unit type and one or two important new combat systems.

A general area of interest to the Army is the use of embedded training systems and simulations. The theoretical benefits and liabilities were discussed earlier. It may be time to conduct a systematic study of these systems. This could be a reasoned discussion of the trade-offs inherent in such systems, attempting to make a more quantitative assessment of the impact these systems could have on increasing training opportunities (for different tasks, at different echelon levels, for example); or it could be a study of early implementations of the technology to determine what benefits are actually realized.

Finally, the ESELDA technology itself could be developed into a more user-friendly package. As a paper exercise, doing many ESELDA analyses would be very tedious. Using

spreadsheet software improves upon the paper model by eliminating certain human errors, and allowing easier examination of "what-if" hypotheses. It might be useful to develop a version of ESELDA using database technology that would guide the user through the determination of input values and perform the computations in a more interactive way. Conceivably, such a system could be structured to facilitate the choice of framing questions, the modification of the questions or rating scales, the input of new questions and scales, etc. It might be possible to create such an application for interactive use via the Internet, or the Internet could be used as a distribution medium for a stand-alone program and documentation. Either way, some of the issues of production and distribution of software and manuals could be avoided.

This project has developed a broad general framework for examining issues concerning the selection and sequencing of training environments. It has provided a decision aid for selecting among environments developed to implement collective training exercises, and it has provided guidance and procedures for developing training sequences or modifying existing sequences. These efforts all support the use of simulation training strategies for Force XXI.

Bibliography

This bibliography contains all references cited in the text, as well as additional sources that were consulted in preparing this report.

Ackerman, Robert K. "Army Intelligence Melds New Doctrine, Technologies: Providing Real-Time Information to Field Commanders Emerges as an Integral Part of the Service's Force XXI." Signal 50 (December 1995): 39-42.

Adams, J. A. (1987). Historical review and appraisal of research on the learning, retention, and transfer of human motor skills. *Psychological Bulletin, 101*, 41-74.

Advanced Warfighting Experiment. <http://www.monroe.army.mil/pao/awe1.htm>

Alley, Lisa. "Army Needs Information Superiority, Teamwork." Army Communicator 22 (Winter 1997): 5-12.

Anderson, Edward G., III. "Space and Missile Defense: A Global Challenge." Army 46 (December 1996): 15-18.

Army Science and Technology Master Plan FY 1997: Volume I and II. March 2, 1997.

Army Training Board (1985). User's manual for predicting military task retention. Ft. Eustis, VA: Author.

Army Training XXI Home Page. <http://www.dcst.monroe.army.mil/atxxi/atxxi-hp.htm>

Army Universal Task List, DA Pamphlet 11-XX (Draft): Dynamic Research Corportation.

Army Vision 2010 Defines 'Full-Spectrum Dominance'." Army 47 (January 1997): 56-57.

Army with information-age technology for Force XXI in the 21st Century." Army 45 (February 1995): 18-22.

Arnold, Edwin, and Vern Lowrey. "Force XXI Engineer Update." Engineer 26 (April 1996): 5-10.

Arnold, Wallace C., and Thomas H. Killion. "MANPRINT (Manpower and Personnel Integration) Battle Command and Digitization." Military Review 75 (May-June 1995): 48-55.

Association of the U.S. Army (1996). Army weaponry, equipment and new technologies, *Army, 46*, (Green Book) 237-312, Arlington, VA:

Author.Association of the United States Army. Army 1997 - 1998 Green Book: Volume 47, October 1997. 305pp.

Association of the United States Army. Briefing Book: America's Army Today and into the 21st Century: Background Briefs and Issue Papers. Arlington, VA: Feb. 1995. 1 vol.

Babb, Joseph, and Curt F. Weimer. "Prairie Warrior 96: Special Operations." Military Review 76 (July-August 1996): 40-47.

Bailey, Timothy J., and others. Mobile Strike Force 2010. Fort Leavenworth: TRADOC Analysis Center, September 1994. 1 vol.

Bateman, Robert L. "Force XXI and the Death of Auftragstaktik." Armor 105 (January-February 1996): 13-15.

Bell, William L., Jr. "Crusader -- Training Force XXI's Firepower." Field Artillery (March-April 1996): 18-19.

Bess, Jeffrey S. Mobile Strike Force: Designing the Force XXI Division. Fort Leavenworth: U.S. Army Command and General Staff College, School of Advanced Military Studies, 1994. 51pp.

Boge, Walter E., and Leonard I. Huskey. "Corps Support to Force XXI." Army RD&A (March-April 1995): 7-9

Boldovici, J. A. (1987). Measuring transfer in military settings. In S. M. Cormier & J. D. Hagman (eds.), *Transfer of learning: Contemporary research and applications.* San Diego, CA: Academic Press.

Bonin, John A. Brigades: Building Blocks for Force XXI. Strategy Research Project. Carlisle Barracks: U.S. Army War College, April 1995. 132pp.

Boyd, Morris J. "Doctrine and Force XXI -- Leading the Army into the 21st Century." <http://204.7.227.75:443/force21/jv/jv-essay/doc&fxxi.html>.

Brooks John R., and Steven L. Campbell. "The EXFOR (Experimental Force): Intelligence in Force XXI." Military Intelligence 22 (April-June 1996): 14-18.

Brown, F. J. (1994). A new training paradigm. In: Holz, R. F., Hiller, J. H., and McFann, H. H. (Eds.) *Determinants of effective unit performance.* Alexandria, VA: U.S. Army Research Institute for Behavioral and Social Science.

Brown, Frederic J. Information Age Training: Converting Potential to Performance. Alexandria, VA: Institute for Defense Analyses, April 1995. 1 vol.

Brown, Thomas E., Jr. "PW (Prairie Warrior) 96: Insights and Observations." Military Review 76 (July-August 1996): 11-16, 18-22.

Bunker, Robert J. "Advanced Battlespace and Cybermaneuver Concepts: Implications for Force XXI." Parameters 26 (Autumn 1996): 108-120.

Bunker, Robert J. "Internetted Structures and C2 Nodes." Military Intelligence 22 (April-June 1996): 26-27.

Burnside, Billy L., Kathleen A. Quinkert, Barbara A. Black, and Lon E. Maggart. "Design of Mounted Warfare Training for Force XXI." Army RD&A (May-June 1995): 13-14.

Cairns, Donald W. "Doctrine Support to Force XXI." Military Intelligence 22 (April-June 1996): 52-53.

Caldwell, John. "Interview with Brigadier General John Caldwell." (Interview centers around the results of the U.S. Army's Task Force XXI Advanced Warfighting Experiment held in March 1997) Jane's Defense Weekly 27 (9 April 1997): 32pp.

Calvo, Mark D. "Digitizing the Force XXI Battlefield." Military Review 76 (May-June 1996): 68-70, 72-73.

Chilcoat, Richard A. "The 'Fourth' Army War College: Preparing Strategic Leaders for the Next Century." Parameters 25 (Winter 1995-1996): 3-17.

Christensen, Eric R. "Communications: Train as You Fight." Military Review 6 (May-June 1996): 31-32.

Christian, Dennis R. A Model for the Seamless Army of the 21st Century. Strategy Research Project. Carlisle Barracks: U.S. Army War College, March 1996. 32pp.

Clancy, John, and Daniel P. Hughes. "New Technology for Force XXI Artillery." Army 46 (February 1996): 46-52.

Coburn, John G. "Focused Logistics -- Projecting and Sustaining Force XXI." Army 46 (October 1996): 127-132.

Crawford, Derrick. "Largest Computer Network to Power Task Force XXI." Pentagram 43 (15 March 1996): 3.

Davison, David A., and Steve Taulbee. "Digitizing the Battlefield." Army RD&A (May-June 1995): 49-51.

Decker, Gilbert F. "21st Century US Army and Equipment Acquisitions." Military Technology 20 (October 1996): 8-10.

Decker, Gilbert F. "The US Army towards Force XXI." (Article emphasizes Army procurement programs) Military Technology 20 (June 1996): 111-117.

Decker, Gilbert F. Fiscal Year 1997 Budget Request and United States Army Technology Programs: Statement by Gilbert F. Decker ... before the Subcommittee on Acquisition & Technology, Committee on Armed Services, United States Senate, Second Session, 104th Congress. Washington: 20 March 1996. 15pp.

Decker, Gilbert F. United States Army Modernization, Fiscal 1997: Statement by Gilbert F. Decker before the Subcommittee on Airland Forces, Committee on Armed Services, United States Senate, Second Session, 104th Congress. Washington: 29 March, 1996. 43pp.

DeGroat, Arthur S., and David C. Nilsen. "Information and Combat Power on the Force XXI Battlefield." Military Review 75 (November-December 1995): 56-62.

Dempsey, Thomas A. Riding the Tiger: Exploiting the Revolution in Military Affairs to Transform the Battlefield. Strategy Research Project. Carlisle Barracks: U.S. Army War College, April 1996. 26pp.

Department of Defense (1991). DoD instruction 5000.2: Defense acquisition management policies and procedures. Washington, D.C.: Author.

Department of the Army. " Army Vision 2010." Wshington, D.C. 18pp.

Department of the Army (1990). "Battle focused training". (FM 25-101). Washington, D.C.: Author.

Department of the Army. (1988, November). "Training the Force". (FM 25-100). Washington, D.C.

Department of the Army. (1989, September). "Corps Operations." (FM 100-15). Washington, D.C.

Department of the Army. (1997, June). "The Digitized Heavy Brigade". (FKSM 71-3-1, Draft). Washington, D.C.

Department of the Army. "Distributed Interactive Master Plan (DIS)." (Sep 1994). Washington, D.C.

Dubik, James M. Creating Combat Power for the 21st Century. Land Warfare Papers, No. 25. Arlington, VA: Association of the United States Army, Institute of Land Warfare, October 1996. 22pp.

Dynamics Research Corporation (1995). User's Manual for the Media Selection Tool (MS Tool). Wilmington, MA: Author.

Electronics Industries Association Study. Pp.145.

Experimental Division Increases Combat Punch." Army 46 (September 1996): 65-66.

Ezell, Virginia H. "In Wake of New Realities, Army Reshapes Warfighting Doctrine: Weapons Technology Requirements Are Revised to Keep Ahead of Burgeoning Mission Spectrum." National Defense 81 (September 1996): 23-24.

Fast, Barbara G. Building Situational Awareness in Force XXI. Strategy Research Project. Carlisle Barracks: U.S. Army War College, April 1996. 43pp.

Force XXI Home Page. <http://204.7.227.75:443/f21home.html>

Forster, William H. "'The Toughest Challenge We Face'." (Equipping the Army for Force XXI) Army 45 (February 1995): 30-34.

Frankel, Michael S. "The 1994 Army Science Board Recommended Technical Architecture for the Digital Battlefield." Army RD&A Bulletin (November-December 1994): 7-11.

Geehan, Brian I. U.S. Army Logistics in the 21st Century and the Challenge of Change. Carlisle Barracks: U.S. Army War College, May 1995. 46pp.

Gilbert, Douglas A. "Leader XXI Campaign Plan." Military Review 76 (January-February 1996): 50-55.

Gill, Clair F. "Terrain Visualization: The Challenge for the Whole Team." Engineer 26 (April 1996): 11-15.

Glaser, R. and Cooley, W. W. (1973). Instrumentation for teaching and instructional management. In R. M. W. Travers (Ed.) *Second handbook of research on teaching*. Chicago: Rand McNally & Company.

Goedkoop, Thomas R. "Forging Task Force XXI." Interview by Dennis Steele. Army 46 (November 1996): 23-25.

Gourley, Scott R. "Army's Force XXI Armored Maneuver Team." (Article focuses on the Abrams and Bradley programs) Army 46 (July 1996): 40-44.

Gourley, Scott R. "Crusader: Fire Support for Force XXI." Army 45 (November 1995): 48-52.

Gourley, Scott R. "Land Warrior." ("The U.S. Army's land warrior program is designed to provide Force XXI dismounted soldiers with a first-generation fighting system.") Army 47 (February 1997): 57-58.

Graham, Scott E. "The Army Research Institute and Force XXI." Army RD&A (May-June 1995): 2-4.

Grange, David L., and James A Kelley. "Victory through Information Dominance." Army 47 (March 1997): 32-37.

Graves, C. R., Campbell, C. H., & Deter, D. E. (In preparation). Combined arms operations at brigade level, realistically achieved through simulation (COBRAS): Report on development and lessons learned (ARI Research Report). Alexandria, VA: U. S. Army Research Institute for the Behavioral and Social Sciences.

Grimsley, D. L. (1969). Acquisition, retention, and retraining: Training category IV personnel with low fidelity devices. (Technical Report 69-12) Monterey, CA: HumRRO Division No. 3 (Recruit Training).

Guenther, Otto, and Robert F. Giordano. "Enabling Technologies and Advanced Concepts for the Digitized Force XXI." Army RD&A Bulletin (November-December 1994): 21-24.

Guenther, Otto. "Software for Force XXI." Army RD&A (March-April 1996): 2-3.

Hagman, J. D. (in press) Use of the engagement skills trainer in predicting rifle marksmanship performance, *Military Psychology.*

Hagman, J. D. and Smith, M. D. (1996). Device-based prediction of tank gunnery performance. *Military Psychology, 8*, 59-68.

Harmeyer, Gen George H. " Air Ground Intergration". Army Aviation (July 31, 1997): 6-12.

Hartzog, William W. "'A Lighthouse of Ideas' on the Road to Force XXI." Army 45 (October 1995): 55-59.

Hartzog, William W. "[Interview with] General William Hartzog, Commanding General, U.S. Army Training and Doctrine Command." Army Times 56 (4 March1996): 31.

Hartzog, William W. "Crossing the Threshold into a New Age." (Article focuses on the U.S. Army Training and Doctrine Command and Force XXI) Army 45 (May 1995): 21-24.

Hartzog, William W. "Leadership and TRADOC XXI." Interview by Patrecia S. Hollis. Field Artillery (June 1995): 4-6.

Hartzog, William W. "On the Road to Force XXI." <http://204.7.227.75:443/force21/jv/jv-essay/roadfxxi.html>.

Hartzog, William W. Statement by General William W. Hartzog ... before the Airland Forces Subcommittee, Senate Armed Services Committee, United States Senate, Second Session, 104th Congress. Washington: 29 March 1996. 9pp.

Hartzog, William W., and Susan Canedy. "Creating Army XXI." Army 46 (October 1996): 53-59.

Hartzog, William W., and Susan Canedy. "Training the 21st Century Army." Army 47 (February 1997): 22-28.

Headquarters, Department of the Army (1988). Mission training plan for the tank and mechanized infantry battalion task force (ARTEP 71-2-MTP). Washington, D.C.: Author.

Headquarters, Department of the Army (1988). Mission training plan for the tank and mechanized infantry battalion task force (ARTEP 71-2-MTP). Washington, D.C.: Author.

Heinemann, Timothy S. Full-Dimension Operations Planning Constructs: Thinking "Out of the Box" for the 21st Century. Fort Leavenworth: U.S. Army Command and General Staff College, School of Advanced Military Studies, 1995. 48pp.

Herbert, Paul H. "Targeting -- A Force XXI Combined Arms Concept." Field Artillery (January-February 1996): 8-10.

Hiller, Jack H., Stewart W. Wallace, Scott C. Marcy, and Robert B. Akam. "Development of a Force XXI Training Management Strategy." Army RD&A (May-June 1995): 10-12.

Hoffman, R. G., Graves, C. R., Koger, M. E., Flynn, M. R. & Seaver, R. S. (1995). Developing the reserve component virtual training program: history and lessons learned. (ARI Research Report 1675) Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences.

Holder, L.D., and Rolland A. Dessert, Jr. "Prairie Warrior: A Joint and Combined Exercise." Military Review 76 (July-August 1996): 5-10.

Holinko, Myron. "Use of the Digital Integrated Lab for Force XXI." Army RD&A (March-April 1996): 9-12.

Holland, John R. "Crusader Update." Field Artillery (January-February 1997): 15pp.

Holz, Robert F., Jack H. Hiller, Howard H. Mcfann: Determinants of Effective Unit Performance: U.S. Army Research Institute for the Behavioral and Social Sciences. July 1994. Pp. 328.

Irby, Dewitt, and Thomas House. "Army Aviation Technology and Concepts." Army RD&A (November-December 1994): 18-20.

Johnson, Eric S. "RAH-66 Comanche -- Eyes and Ears for the 21st Century." Field Artillery (May-June 1996): 22-25.

Joint Venture Home Page. <http://jointventure.monroe.army.mil/>

Joint WarFighter Center. "Joint Simulations System Concept of Operations". Version 1.0. (August 15, 1997). Pp. 90.

Jones, Harry E., II. "Information Dominance for Army XXI: Battlefield Visualization." Military Intelligence 23 (January-March 1997): 8-10.

Jones, Philip M. "Force XXI and the Principles of Military Operations Other Than War." March 1995. <http://204.7.227.75:443/force21/articles/principl.html>.

Jordan, Larry R. "FOCUSED DISPATCH: The Mounted Piece of Force XXI." <http://204.7.227.75:443/force21/jv/jv-essay/jordan.html>.

Joint Warfighter Center. "JSIMS ORD" (Feburary 1996). 25pp.

Joint Warfighter Center. "JSIMS Concept of Operations." (August 1997). 90 pp.

Kahan, J. P., Webb, N., Shavelson, R. J. & Stolzenberg, R. M. (1985). Individual characteristics and unit performance: A review of research and methods. R-3194-MIL. Santa Monica, CA: RAND Corporation.

Keenan, J. M., Keesling, J. W., and Graney, P. T. (1996). Comprehensive report on the preparation of validated training strategies for Army battalions. Monterey, CA: U.S. Army Research Institute for Behavioral and Social Research.

Keesling, J. W., and Ford, P. (1997). Relationship among unit characteristics, OPTEMPO, and unit performance. Monterey, CA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Killebrew, Robert B. "The Army After Next: TRADOC's Crystal Ball Eyes the Service's Shape beyond Force XXI." Armed Forces Journal International 134 (October 1996): 36-45.

King, David M. Force XXI and the American Way of War. Fort Leavenworth: U.S. Army Command and General Staff College, School of Advanced Military Studies, 1995. 52pp.

Knapp, D. J., Ford, J. P., and Hoffman, R. G. (1997). Army reserve component research roadmap (Volume 2): Research agenda. FR-EADD-97-20. Alexandria, VA: Human Resources Research Organization (HumRRO).

Knapp, M. I. and Orlansky, J. (1983). *A cost element structure for defense training*. IDA Paper P-1709. Alexandria, VA: Institute for Defense Analyses.

Kollhoff, Ronald K. "The Lessons of Operation Desert Hammer VI: Training: Digitization Will Impact Many Areas of Training." Armor 104 (September-October 1995): 41-43.

Kominos, Catherine. "20th Army Science Conference Highlights Force XXI Technology." Army RD&A (September-October 1996): 17-19.

Kribs, H.D., Simpson, A.C., and Mark, L.J. (1983). Automated instructional media selection (AIMS). (NAVTRAEQUIPCEN 79-C-0104-1). San Diego: Instructional Science and Development, Inc.

Leibstone, Marvin. "US Army Equipment & Force XXI." Military Technology 19 (December 1995): 10-14.

Leonhard, Robert R. "Force XXI and the Theory of Winning Outnumbered." Army 46 (June 1996): 56-64.

Lionetti, Donald M. "Poised to support Force XXI ." (US Army Space and Strategic Defense Command) Army 44 (October 1994): 173-177.

Longhouser, John E. "Converting Computing Power into Combat Power. Army RD&A (March-April 1996): 4-8.

Lunceford, W.H. "Some Emerging Trends in Military Simulations." Speech delivered at Georgia Tech (Oct 97).

Macgregor, Douglas A. Breaking the Phalanx: A New Design for Landpower in the 21st Century. USAWC Fellowship Research Project. Carlisle Barracks: U.S. Army War College, May 1996. 225pp.

Maggart, Lon E. "Cavalry in Force XXI." Armor 105 (September-October 1996): 11-13. March 14, 1997.

Marlin, David W. "Army Training XXI: The Army's Future Training Strategy." Military Review 76 (May-June 1996): 46-51.

Martin, William C. "Training in the 21st Century -- The Force XXI Training Program." Armor 104 (May-June 1995): 40-41.

Martinez, Erasmo A. "Division XXI Intelligence Operations." Military Intelligence 22 (April-June 1996): 19-22.

Matthys, Erik T. "Harnessing Technology for the Future." Military Review 75 (May-June 1995): 71-76.

Matto, E. J., & Moses, F. L. (1997) Prototype procedures for optimizing training strategies. (Technical Report 1067) Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

McDuffie, John M. "Force XXI Corps Support." Army Logistician (July-August 1995): 26-31.

Menoher, Paul E., Jr. "Fielding New Systems for Today's Army and Army XXI." (Army Intelligence) Army 46 (October 1996): 135-140.

Menoher, Paul E., Jr. "Force XXI: Redesigning the Army through Warfighting Experiments." Military Intelligence 22 (April-June 1996): 6-8.

Metz, Steven. " Strategic Horizons: The Military Implications Of Alternative Futures." (March 1997). Strategic Studies Institute. 58pp.

Miller, John E., and Kurt C. Reitinger. "Force XXI Battle Command." Military Review 75 (July-August 1995): 5-9.

Murty, K. G., Djang, P., Butler, W., & Laferriere, R. (1995) The Army training mix model. *Journal of the Operational Research Society, 46,* 294-303.

Naylor, J. C. (1962). Parameters affecting the relative efficiency of part and whole training methods: A review of the literature (NAVTRADEVCEN 950-1). Port Washington, NY: U.S. Naval Training Device Center.

Naylor, Sean D. "'Next' Up: Looking beyond Force XXI: Army's Newest Project Takes Tactical Look at Warfare in the Years between 2010 and 2025." Army Times 56 (10 June 1996): 18.

Naylor, Sean D. "Digitized Brigade Struts Its Stuff in First Action." Army Times 57 (13 January 1997): 45-46.

Naylor, Sean D. "EXFOR (Experimental Force): Facing Challenges Head On." Army Times 57 (18 November 1996): 28, 30.

Naylor, Sean D. "Three Options for Four Stars: Army Weighs Choices to Decide Direction of the Future Division (Force XXI)." Army Times 56 (16 October1995): 12-14.

Nifrong, Michael R. "The Key to Information Dominance." Military Review 76 (May-June 1996): 62-67.

Ohle, David H., and John M. Spiszer. "Providing Coherence for Training Force XXI." Military Review 76 (July-August 1996): 63-69.

Owens, William A. "The Emerging System of Systems." Military Review 75 (May-June 1995): 15-19.

Olyer, Jim. "The Battlefield in your Mind." Military Training Technology (June /July 1997). 8-11.

Patten, George, and Craig Langhauser. "The World's First 21st Century Tank." Army RD&A (March-April 1997): 16-19.

Patten, George, and Jimmy W. Whiteley. "The World's First Information Age Ground Combat Weapon System." (M1A2 Abrams Main Battle Tank) Army RD&A (September-October 1996): 23-27.

Pearson, Paul F., and Glenn K. Otis. "Crusader: Linchpin of the Force XXI Army." Army 46 (November 1996): 45-47. 134 (October 1996): 30-32.

Petrosky, MG Daniel J. "Army Aviation In the Future Fight". Army Aviation (June 30, 1997): 10 -15.

PM DIS, OneSAF Integrated Concept Team Requirements Sub Group. " One Semi- Automated Forces (OneSAF) Requirements." (September 17, 1997). Pp. 43.

Prevou, Michael I. The Battle Command Support System: A Command and Control System for Force XXI. Fort Leavenworth: U.S. Army Command and General Staff College, School of Advanced Military Studies, 1994. 81pp.

Reimer, Dennis J. Army Vision 2010. Washington: U.S. Department of the Army. 1996. 18pp.

Reimer, Dennis J., Togo D. West, and William W. Hartzog. Force XXI, America's Army in Transition: Process of Change to a Capabilities Based Army. Fort Monroe: U.S. Army Training and Doctrine Command, Commander's Planning Group, 1996. 16pp.

Rigby, Joseph W. "Digitizing Force XXI: A Team Effort." Army 45 (May 1995): 36-44.

Rigby, Randall L. "Fires for Division XXI: State of the Branch 1995." Field Artillery (November-December 1995): 1-5.

Rigby, Randall L. "Shaping Battlespace: More Than Just Deep Attack." Field Artillery (November-December 1995): 12-14.

Rigby, Randall L. "Targeting UAVs (Unmanned Aerial Vehicles) -- The Need Is Great, The Time Is Now." Field Artillery (January-February 1997): 1pp.

Roos, John G. "Wizard Warrior: Even Though Its Debut Is Two Decades Away, the Next-Generation Tank Is Already in the Spotlight." Armed Forces Journal International 134 (June 1996): 24-31.

Rosenberger, John D. "A Year in the EXFOR (Experimental Force)." Army 46 (November-December 1996): 26-29.

Russell, Theodore S., Jr., and Harold H. Worrell, Jr. "Focus on Light Force XXI: AWE (Advanced Warfighting Experiment) Warrior Focus." Field Artillery (May-June 1996): 36-39.

Salomon, Leon E. "Army Aviation's Contribution to Force XXI." Army Aviation 44 (31 January 1995): 6-12.

Schlussel, Kent, Ben A. Farmer, Jr., and Paul A Zimmerman. "Support to Force XXI: Land Capability Spectrum Model." Military Intelligence 22 (April-June Science Applications International Corporation. Strategic Assessment Center. Proceedings of Workshop III on Dominating Maneuver and the RMA (Revolution in Military Affairs). (Workshop conducted 19-21 September 1995 at the U.S. Army War College, Center for Strategic Leadership, Carlisle Barracks, PA.) McLean,VA: Science Applications International Corporation, 1995. 1 vol.

Schmidt, Tom. Coordinating Draft: Army Training XXI Campaign Plan. (July 8, 1997)

Seffers, George I. "Experiment: Two Revolutions in One: Advanced Warfighting Test Exhibits New Technologies, Acquisition Methods." Army Times 57 (7 April1997): 26.

SHERIKON, Inc. (1995). *Task performance support (TPS) codes: A means to allocate MTP tasks to simulation-based collective training events.* Orlando, FL: Author.

Sherman, Jason. "21st Century Tank: US Army Lays Plan for Its Next Generation of Armored Warriors." Armed Forces Journal International 134 (October 1996): 46-51.

Simpson, H. (1995). *Cost-effectiveness analysis of training in the department of defense.* DMDC Technical Report 95-004. Seaside, CA: Defense Manpower Data Center.

Skurka, J. (1997) Synthetic environment acquisition support. Presented at: Office of the Secretary of Defense/Army Modeling and Simulation for Test and Evaluation Conference. Orlando, FL: STRICOM.

Snider, James R. "RAH-66 COMANCHE: Centerpiece of the Peacekeeping Force." Military Technology 19 (July 1995): 25-27.

Starry, Michael, and Charles W. Arneson, Jr. "FM 100-6: Information Operations." Military Review 76 (November-December 1996): 3-15.

Starry, Michael, and Kevin LeMar. "It's Not the Same Old Army: A New World Demands a New Force." Armed Forces Journal International 133 (October 1995): 38-42.

Steele, Dennis. "Task Force XXI Advanced WarFighting Experiment at NTC." Army (Vol. 47 May 1997). 14-23.

Steele, Dennis. "Countdown to the Next Century." (Article focuses on Task Force XXI) Army 46 (November 1996): 16-22.

Steele, Dennis. "Day of the Javelin." Army 47 (February 1997): 33-39.

Stewart, John F. "Intelligence Strategy for the 21st Century." Military Review 75 (September-October 1995): 75-81.

Sticha, P. J., Schlager, M., Buede, D., Epstein, K., and Blacksten, H. (1990). *Specifying skill-based training strategies and devices: A model description.* FR-PRD-90-01. Alexandria, VA: Human Resources Research Organization (HumRRO).

Straffon, Nicholas L. "From Technology to Capability: The Case for Innovation : Will Our Acquisition and Combat Development Leaders Select the Right Systems?" Army RD&A (July-August 1995): 23-25.

Sullivan, Gordon R. "'A New Force for a New Century'." Army 44 (May 1994): 24-26.

Sullivan, Gordon R. "Force XXI: Digitizing the Battlefield." Army RD&A Bulletin (November-December 1994): 2-3.

Sullivan, Gordon R., and Anthony M. Coroalles. Seeing the Elephant: Leading America's Army into the Twenty-First Century. National Security Paper, No. 18. Cambridge, MA: Institute for Foreign Policy Analysis, 1995. 74pp.

Sullivan, Gordon R., and Anthony M. Coroalles. The Army in the Information Age. Carlisle Barracks: U.S. Army War College, Strategic Studies Institute, March 1995. 22pp.

Taylor, Charles W. " A World 2010: A New World Order of Nations." (1992) Strategic Studies Institute, U.S. Army War College,. 125pp.

Terpeluk, William. Lessons from the Past and a Vision of the Future: Tactical Headquarters Requirements in Force XXI. Strategy Research Project. Carlisle Barracks: U.S. Army War College, April 1995. 34pp.

The Future of Defense Electronics: "Forecasting Into the 21st Century". (October 1996).

The M1A2: Current and Future Program Plans. Armor Magazine (May - June 1996): Pp. 6.

Thomas, Charles W., and Cary C. Harbaugh. "The Military Intelligence Vision for the XXI Century." Military Intelligence 22 (April-June 1996): 9-13.

Thorson, Steve, and Bruce Held. "Training Ammunition for Force XXI." Armor 105 (May-June 1996): 21-25, 36.

Tilford, Earl H., ed. World View: The 1997 Strategic Assessment from the Strategic Studies Institute. Carlisle Barracks: U.S. Army War College, Strategic Studies Institute, February 1997. 80pp.

TRADOC (Training and Doctrine Command) (1994). Tactical engagement simulation training system master plan. Ft. Monroe, VA: Author.

U.S. Army Battle Labs Home Page. <http://battlelabs.monroe.army.mil/>

U.S. Army Combined Arms Center. "Training and Doctrine Command" (August 1995) Handbook for Commanders and Trainers.

U.S. Army Digitization Office Home Page. <http://www.ado.army.mil/>

U.S. Army Digitization Office. U.S. Army Digitization Master Plan. Washington: March 1996. 1 vol.

U.S. Army STRICOM. "Avaition Reconfigurable Simulators (ARMS) Training Strategy". (Draft) June 20, 1997. Pp. 29.

U.S. Army STRICOM. Command Forecast FY 1997- 2001. December, 1996. Pp 44.

U.S. Army Training and Doctrine Command. (no date) "Requirement Determination." Pamplet. Pp. 18.

U.S. Army Training and Doctrine Command. Director for Battle Lab Integration and Technology. Battle Labs: Maintaining the Edge. Fort Monroe: May 1994. 35pp.

U.S. Army Training and Doctrine Command. Director for Battle Lab Integration, Technology and Concepts. Battle Labs Force XXI: Defining the Future. Fort Monroe: May 1995. 27pp.

U.S. Army Training and Doctrine Command. Force XXI Operations: A Concept for the Evolution of Full-Dimensional Operations for the Strategic Army of the Early Twenty-First Century. TRADOC Pamphlet 525-5. Fort Monroe: 1 August 1994. 1 vol.

U.S. Department of the Army. Army Focus 94: Force XXI: America's Army in the 21st Century. Washington: September 1994. 1 Vol.

U.S. Department of the Army. Office of the Chief of Public Affairs. Speech File Service. Washington: 3rd Quarter, Fiscal Year 1994. 19pp. Pp. 8-12: "Digitizing for a 21st Century Force," by Gordon R. Sullivan.

U.S. Department of the Army. Office of the Chief of Staff. Louisiana Maneuvers Task Force. Force XXI, America's Army of the 21st Century: Meeting the 21st Century Challenge. Fort Monroe: 1995. 33pp.

U.S. Department of the Army. Office of the Deputy Chief of Staff for Operations and Plans. The United States Army 1995 Modernization Plan. Washington: 1995. 1 vol.

U.S. Department of the Army. Office of the Deputy Chief of Staff for Operations and Plans. The United States Army 1996 Modernization Plan. Washington: 1996. 1 vol.

Vane, Michael A. "Some Future Challenges in Information Warfare." February 1995. <http://204.7.227.75:443/force 21/articles/future.html>.

Wass de Czege, Huba. "Mobile Strike Force: A 2010 Potential Force." Military Review 76 (July-August 1996): 70-84.

Watts, Ronald L. "Joint STARS (Joint Surveillance Target Attack Radar System): A Force XXI Enabler." Military Review 76 (November-December 1996): 19-22.

Weaver, Vince C., Jr. "Fires in AWE (Advanced Warfighting Experiment) Focused Dispatch - A Step toward Task Force XXI." Field Artillery (March-April 1996): 38-40.

Wegner, Neal J. "Introduction to the Intel XXI Concept." Military Intelligence 22 (April-June 1996): 51-52.

West, Togo D., Jr., and Dennis J. Reimer. Meeting the Challenges of Today, Tomorrow, and the 21st Century: A Statement on the Posture of the United States Army, Fiscal Year 1997. Posture Statement presented to the 104th Cong., 2d sess. Washington: U.S. Department of the Army, 1996. 78pp. Pp: 66-75: "America's Army Tomorrow and into the 21st Century."

West, Togo D., Jr., and Dennis J. Reimer. Soldiers Are Our Credentials: America's Army - The Force of Decision for Today, Tomorrow, and the 21st Century: A Statement on the Posture of the United States Army, Fiscal Year 1998. Posture Statement presented to the 105th Cong., 1st sess. Washington: U.S. Department of the Army, 1997. 55pp. Pp: 49-55: "Into the 21st Century."

West, Togo D., Jr., and Gordon R. Sullivan. Serving the Nation: A Statement on the Posture of the United States Army, Fiscal Year 1996. Posture Statement presented to the 104th Cong., 1st sess. Washington: U.S. Department of the Army, 1995. 139pp. Pp. 49-71: "Building Force XXI."

White, David C., and Clyde W. Ellis. "Army Training XXI." Field Artillery (March-April 1996): 8-10.

Wightman, D., Adams, R. E., and Gainer, C. A. (1995). The role of flight simulation in the Force XXI Army. *Army RD&A,* May-June, PB-70-95-3, 15-17.

Willebrand, Guy E. "FA (Field Artillery) Training Devices for 1990s and Beyond." Field Artillery (March-April 1996): 11-13.

Wilson, Johnnie E., and Roberto Capote. "Leveraging Logistics Technology toward Force XXI." Army Logistician (July-August 1995): 14-18.

Wisher, R. A., Sabol, M. A., and Ozkaptan, H. R. (1996). Retention of "peace support operations" tasks during Bosnia deployment: A basis for refresher training. (Special Report) Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Woznick, John C. "TERM: The Tank Extended Range Munition." Armor 106 (March-April 1997): 21-23.

Appendix A

Acronyms/Glossary

A2C2	Army Airspace Command and Control
A2C2S	Army Airborne Command and Control System
AA	Assembly Area; Axis of Advance; Avenue of Approach
AAN	Army After Next
AAPS	Advanced Antenna Prototype Subsystem
AAR	Advance Arrival Report; After Action Review
ABCS	Army Battle Command System
AC	Active Component
ACA	Airspace Coordination Area
ACR	Advanced Concept Requirements
ACT	Advanced Cargo Transport
AD	Air Defense
ADA	Air Defense Artillery
ADAM	Area Denial Munitions
ADCATT	Air Defense Combined Arms Tactical Trainer
ADO	Air Defense Officer
ADSO	Assistant Division Signal Officer
AFATDS FED	AFATDS Forward Entry Device
AFATDS LCU	AFATDS Lightweight Computer Unit
AFATDS	Advanced Field Artillery Tactical Data System
AGCCS	Army Global Command and Control System
AGES	Air to Ground Engagement System
AGTS	Advanced GunneryTraining System
AIMS	Automated Instruction Media Selection
ALOC	Administration/Logistics Operations Center
ALSP	Aggregate Level Simulation Protocol
AMP	Army Modernization Plan
AMPS	Aviation Mission Planning System

AMTP	Army Mission Training Plan
AMW	Amphibious Warfare
ANBACIS	Automated Nuclear, Biological, and Chemical Information System
AO	Area of Operations
AP	Antipersonnel
APDS	Armor-piercing Discarding Sabot
APERS	Antipersonnel
APPLIQUÉ	Primary Command and Control System Which Provides Situational Awareness
APS	Army Posture Statement
AQF	Advanced Quick Fix
ARCIS	Army Company Information System
ARMS	Aircraft Reconfigurable Manned Simulators
ART	Army Tactical
ARTEP	Army Training Exercise Plan
AS	Autonomous System
ASAS	All Source Analysis System
ASAS RWS	ASAS Remote Workstation
ASTMP	Army Science and Technology Plan
ASSET IV	Aircraft Survivability Equipment Trainer
AT	anti-tank
ATA	Army Technical Architecture
ATACMS	Army Tactical Missile System
AT XXI	Army Training XXI
ATCCS	Army Tactical Command and Control System
ATCMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
ATGM	Antitank Guided Missile
ATK	Attack
ATM	Asynchronous Transfer Mode
ATSC	US Army Training Support Center

ATXXI	Army Training XXI
AVCATT	Aviation Combined Arms Tactical Trainer
AVLB	Armored Vehicle Launch Bridge
AVTOC	Aviation Tactical Operations Center
AWACS	Airborne Warning And Control System Awareness For Brigade and Below
AW	Air Warfare
AWE	Advanced Warfighting Experiment
AUTL	Army Universal Task List
B2C2	Brigade and Below Command and Control
BADD	Battlefield Awareness and Data Dissemination
BBS	Brigade/Battalion Battle Simulation
BCIS	Battlefield Combat Identification System
BCT	Brigade Combat Team
BCTP	Battle Command Training Program
BDE	Brigade
BFA	Battlefield Functional Area
BFIST	Bradley Fire Support Team
BFV	Bradley Fighting Vehicle
BGP	Border Gateway Protocol
BGT	Bradley Gunnery Training
BIDS	Biological Integrated Detection System
BLUEFOR	Blue Forces
BN; bn	Battalion
BN/TF; bn/TF	Battalion/Task Force
BOS	Battlefield Operating System
BRIL	Baseline Resource Item List
BSV	Bradley Stinger Fighting Vehicle
BSFV-E	Bradley Stinger Fighting Vehicle-Enhanced
BTL STF	Battle Staff

C2	Command and Control
C2A	Command and Control Attack
C2V	Command and Control Vehicle
C2W	Command and Control Warfare
C3	Command, Control, and Communications
C3I	Command, Control, Communications, and Intelligence
C4I	Command, Control, Communications, Computers, Intelligence
CA	Civil Affairs; Combat Assessment; Combined Arms
CAI	Computer-Assisted Instruction
CALFEX	Combined Arms Live Fire Exercise
CALL	Center for Army Lessons Learned
CATS	Combined Arms Training Strategies
CATT	Combined Arms Tactical Trainer
CBI	Computer Based Instruction
CBS	Corps Battle Simulation
CCIR	Commanders Critical Information Requirements
CCTT	Close Combat Tactical Trainer
CD-ROM	Compact Disc-Read Only Memory
CDMA	Code Division Multiple Access
CDMP	Combat Decision-Making Process
CDR; cdr	Commander
CFF	Call For Fire
CFV	Cavalry Fighting Vehicle
CFX	Command Field Exercise
CFZ	Critical Friendly Zone
CG	Commanding General
CGS	Common Ground Sensor
CID	Commander's Integrated Display
CINC	Commander In Chief
CIS	Commander's Independent Sight; Core Instrumentation Subsystem
CISCO	Manufacturer's name of a commercial modular access router

CITV	Commander's Independent Thermal Viewer
CIU	Crew Interface Unit
CLAMMS	Cleared Lane Mechanical Marking System
CLU	Command Launch Unit
CMD	Command
CMTC	Combat Maneuver Training Center
CO CDR	Company Commander
Co/tm	Company/Team
COA	Course of Action
COE	Common Operating Environment
COLT	Combat Observation Lazing Team
COM	Communication Port (e.g., COM 1)
COMMINT	Communications Intelligence
COMSEC	Communications Security
CONUS	Continental United States
Copperhead	Cannon-Launched guided projectiles
COSCOM	Corps Support Command
COTS	Commercial Off-The-Shelf
CP	Command Post
CPT	Captain
CPX	Command Post Exercise
CR	Counter-Reconnaissance
CRP	Common Relevant Picture
CS	Combat Support
CSS	Combat Service Support
CSSCS	Combat Service Support Control System
CSSTSS	Combat Service Support Training Simulation System
CTC-IS	Combat Training Center - Instrumentation System
CTC	Combat Training Center
CTIL	Commander's Tracked Items List
CTIS	Combat Terrain Information System

CTS	Combat Training Support
DA	Department of the Army
DAMA	Demand Assignment Multiple Access
DAO	Division Ammunition Officer
DBC	Digital Battlefield Communications
DBS	Direct Broadcast Satellite
DCE	Distributed Computing Environment
DDS	Data Distribution System
DDU	Driver's Display Unit
DEPEX	Deployment Exercise
DEW	Directed Energy Weapons
DF	direction finding
DID	Driver's Integrated Displays
DIS	Distributed Interactive Simulation
DISCOM	Division Support Command
DISE	Deployable Intelligence Support Element
DISN	Defense Information System Network
DIV	Division
DIVARTY	Division Artillery
DL	Distance Learning
DMP	Decision Making Process
DNVT	Digital Non-secure Voice Terminal
DOA	Direction of Attack
DOD	Department of Defense
DPG	Defense Planning Guidance
DPICM	Dual-Purpose Improved Conventional Munitions
DRAM	Dynamic RAM
DRS	Digital Recon System
DS	Direct Support
DSA	Direct Support Area

DSS	Dismounted Soldier System
DSSU	Dismounted Soldier System Unit
DST	Decision Support Template
DSVT	Digital Secure Voice Terminal
DTG	Date-Time Group
DTSS	Digital Topographic Support System
DU	Display Unit; Depleted Uranium

EAB	Echelons Above Brigade
EAC	Echelons Above Corps
EAD	Echelons Above Division
ECB	Echelons Corps and Below
ECCM	Electronic Counter-Counter Measures
ECM	Electronic Counter Measures
EDM	Enhanced Data Mode
EDRE	Emergency Deployment Readiness Exercise
EEFI	Essential Elements of Friendly Information
EFOGM	Enhanced Fiber Optic Guided Missile
ELINT	Electronic Intelligence
ELSEC	Electronic Security
EM	electro-magnetic
EMUT	Enhanced Manpack UHF Terminal
ENG	Engineer
ENCATT	Engineer Combined Arms Tactical Trainer
EO	Electro-Optical
EPLRS	Enhanced Position Location Reporting System
EPLRS VHSIC	EPLRS Very High Speed Integrated Circuit
EPW	Enemy Prisoner of War
ES	Electronic Support; embedded simulation
ESELDA	Environment Selection Decision Aid
ET	embedded training

ETC	electro-thermal-chemical
ETPT	Embedded Troop Proficiency Trainer
Evac	Evacuate
EVENTEMP	Event Template
EW	Electronic Warfare
EXEVAL	External Evaluation
FA	Field Artillery
FAAD	Forward Area Air Defense
FAADC2I	Forward Area Air Defense Command, Control, and Intelligence
FAADC3I	Forward Area Air Defense Command, Control, Communications, and
FAMSIM	Family of Simulations
FASCAM	Family of Scatterable Mines
FBCB2	Force XXI Battle Command Brigade and Below
FCL	Final Coordination Line; Fire Coordination Line
FCR	Future Digital Radio
FCX	Fire Coordination Exercise
FDC	Fire Direction Center
FDR	Future Digital Radio
FFIR	Friendly Forces Information Requirements
FH MUX	Frequency Hopping Multiplexer
FH-M	Frequency Hopping-Master Fire, and Cover and Concealment
FIREFINDER	Firefinder Radar (AN/TPQ-36)
FIST	Fire Support Team
FIST-V	Fire Support Team Vehicle
FKSM	Fort Knox Supplemental Material
FLIR	Forward Looking Infrared
FM	Frequency Modulation; Field Manual
FPD	Flat Panel Display
FPF	Final Protective Fires
FRAGO	Fragmentary Order

FS	Fire Support
FSB	Forward Support Battalion
FSC	Forward Support Company
FSCL	Fire Support Coordination Line
FSCM	Fire Support Coordination Measures
FSCATT	Fire Support Combined Arms Tactical Trainer
FSCOORD	Fire Support Coordinator
FSE	Fire Support Element
FTT	Field Tactical Trainer
FTX	Field Training Exercise
FXXI	Force XXI
G/VLLD	Ground/Vehicular Laser Location Device
GBCS	Ground Based Common Sensor
GBS	Global Broadcast Service
Gbytes	Gigabytes
GCCS	Global Command and Control System
GMLRS	Guided Multiple Launch Rocket System
GPR.	Ground Penetrating Radar
GPS	Global Positioning System
GSR	Ground Surveillance Radar; General Support Reinforcing
GTA	Graphic Training Aid
GTN	Global Transportation Network
HCTR	High Capacity Trunk Radio
HE	High Explosive
HEAT	High Explosive-Antitank
HEMMS	Hand Emplaced Minefield Marking Set
HF	high frequency
HFE	Human Factors Engineering
HHC	Headquarters and Headquarters Company

HHS	Hand Held SINCGARS SIP
HIMAD	High-to-Medium Altitude Air Defense
HLA	High Level Architecture
HMD	Helmet-Mounted Display
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HPT	High-Payoff Targets
HPTL	High-Payoff Target List
HS3	Hunter Sensor Surrogate System
HIS	Homestation Instrumentation
HTU	Handheld Terminal Unit
HVT	High-Value Targets
HVTL	High-Value Target List
I/O	Input/Output
IAW	In Accordance With
ICCR	Integrated Circuit Chip Reader
ICM	Improved Conventional Munitions
ICOM	Integrated Communications Security
ID	Identification
IDM	Improved Data Modem
IDS	Information Dissemination Server
IEEE	Institute of Electrical and Electronics Engineers
IEW	Intelligence and Electronic Warfare
IEWCS	Intelligence and Electronics Warfare Common Sensor
IFF	Identification, Friend, or Foe
IFV	Infantry Fighting Vehicle
IHFR	Improved High Frequency Radio
ILS	Integrated Logistics Support
IMETS	Integrated Meteorological System
IMF	Intelligent Minefield
INC	Internet Controller

INFOSEC	Information Security
INFOSYS	Information Systems
INTEL; intel	Intelligence
INTSUM	Intelligence Summary
IO	Information Operations
IOC	Initial Operational Capability
IOS	Internetwork Operating System
IP	Intervention Points; Internet Protocol
IPB	Intelligence Preparation of the Battlefield
IR	Infrared
IREMBASS	Improved Remotely Monitored Battlefield Sensor System
ISDN	Integrated Services Data Network
IVIS	Inter-Vehicular Information System
JANUS	Interactive, computer-based, war-gaming simulation of combat operations conducted by individual platoons through brigade.
JBPDS	Joint Bio Point Detection System
JCAT	Joint Conflict and Tactical Simulation
JCM	Joint Conflict Model
JMETL	Joint Mission-Essential Task List
JMETL	Joint Mission Essential Task List
JRTC	Joint Readiness Training Center
JSCP	Joint Strategic Capabilities Plan
JSEAD	Joint Suppression of Enemy Air Defense
JSIMS	Joint Simulation System
JSOW	Joint Stand-Off Weapon
JSTARS	Joint Surveillance Target Attack Radar System
JTF	Joint Task Force
JTIDS	Joint Tactical Information Distribution System
KB	Kilobytes

Kbps	Kilobytes per second
KE	Kinetic Energy
KM; km	Kilometers
KMPH; kmph	Kilometers Per Hour
LAN	Local Area Network
LCD	Liquid Crystal Display
LCN	Logical Channel Number
LCU	Lightweight Computer Unit
LDR; ldr	Leader
LEO	low earth orbit
LIC	Low Intensity Conflict
LINC	Lightweight Internet Controller
LLDR	Lightweight Laser Designator/Range Finder
LNO	Liaison Officer
LOC	Line Of Communication
LOS	Line Of Sight
LP	liquid propellant
LPI	Low Probability of Intercept
LRAS3	Long Range Acquisition Scout Sensor Suite
LRF	Laser Range Finder
LRU	Line Replacement Units
LTA	Launch Tube Assembly
LW	Land Warrior
LWIR	long wave infrared
LZ	Landing Zone
MAIS	Mobile Automated Instrumentation Suite
M&S	Models and Simulations
MARCS	Multi-Technology Automated Reader Card Systems
MARSIM	Maritime Simulation

MCS/P	Maneuver Control System / Phoenix
MEA	Munitions Effects Assessment
MEL	Master Events List
METL	Mission Essential Task List
METT-T	Mission, Enemy, Terrain, Troops and Time available
METT-TC	Mission, Enemy, Terrain, Troops, Time available, and Civilians
MFCS	Mortar Fire Control System; Multi-Functional Computer System
MGRS	Military Grid Reference System
MHz	MegaHertz
MI	Military Intelligence
MIC	Mid Intensity Conflict
MICAD	Multi Purpose Integrated Chemical Agent Detector
MICLIC	Mine-Clearing Line Charge
MIE	Military Information Environment
MIL	Military
MILES	Multiple Integrated Laser Engagement System
MIN	Minimum
MLRS	Multiple Launched Rocket System
MMS	Mast Mounted Sight
MMW	millimeter wave
MNS	.Mission Need Statement
MO	Magneto Optical
MODEM	Modulation/Demodulation
ModSAF	Modular Semi-Automated Forces
MOPP	Mission Oriented Protective Posture
MOUT	Military Operations on Urbanized Terrain
MPAT	Multipurpose Antitank
MPN	MSE Packet Network
MPRS	Mission Planning and Rehearsal System
MRS	Muzzle Reference System
MSE	Mobile Subscriber Equipment

MSG	Multiple Source Group; Message
MSI	Multispectral Imagery
MSR	Missile Simulated Round
MSRT	Mobile Subscriber Radio Terminals
MTI	Moving Target Indicator
MTOE	Modified Table of Organization and Equipment
MTP	Mission Training Plans
MTS	Movement Tracking System
NBC	nuclear, biological, chemical
NBCRS	NBC Recon System
NCO	Non-Commissioned Officer
NCOIC	Non-Commissioned Officer In Charge
NCS	Net Control Station
NCS-E	Net Control Station-EPLRS
NETID	Network Identifier
NMS	National Military Strategy
NSC	National Simulation Center
NTC-IS	National Training Center
NTC	National Training Center
NTDR	Near term Digital Radio
O/C	Observer/Controller
OBJ	Objective
OC	Observer Controller
OCSW	Objective Crew Served Weapon
OICW	Objective Individual Combat Weapon
ONESAF	One Semiautomated Forces
OOTW	Operations Other Than War
OP	Observation Post
OPCON	Operational Control

OPFAC	Operational Facility
OPFOR	Opposing Forces
OPLAN	Operations Plan
OPORD	Operations Order
OPSEC	Operations Security
OPTEMPO	operating tempo
OPW	Objective Personal Weapon
ORSMG	Off Road Smart Mine Clearance
OTM	on-the-move
PAC III	Patriot Advance Capability III
PACA	Phased Array Communications Antenna
PCS	Personal Communication Satellite
PGS	Precision Gunnery System
PRIME	Precision Integrated Maneuver Exercise
PKO	Peace keeping Operations
PLGR	Precision Lightweight GPS Receiver
PLT; plt	Platoon
PLT Ldr	Platoon Leader
PND	Position Navigation Device
POS/NAV	Position/Navigation
PRC-119	SINCGARS SIP Backpack Radio
PSG	Platoon Sergeant
PSS	Personnel Service Support
PSTN	Public Switched Telephone Network
PSYOP	Psychological Operations
R&S	Reconnaissance and Surveillance
RAAM	Remote Antiarmor Mines
RAM	Random Access Memory
RAP	Radio Access Point

RAPIDS	Real-Time Automated Personnel Identification System
RC	Reserve Component
RDA	Research Development and Acquisition
RDMS	Range Data Measurement Subsystem
RETRANS	Retransmission
RF	Radio Frequency
RFI	Request For Information; Radar Frequency Interferometer
RISTA	Reconnaissance, Intelligence, Surveillance, and Target Acquisition
RIU	Radio Interface Unit
RMCS	Range Monitoring and Control Subsystem
ROE	Rules Of Engagement
S1	Adjutant
S2	Intelligence Officer
S3	Operations and Training Officer
S4	Supply Officer
SA	Situational Awareness
SADARM	Search and Destroy Armor
SAF	Semi-Automated Forces
SAM	surface-to-air missile
SAR	Synthetic Aperture Radar
SATCOM	satellite communications
SATS	Standard Army Training System
SAWE	Simulated Area Weapons Effects
SCSI	Small Computer System Interface
SDR	Surrogate Digital Radio (Formerly SDR)
SE	Synthetic Environment
SEAD	Suppression of Enemy Air Defense
SEN	Small Extension Node
SEP	Systems Enhancement Program
SHF	Super High Frequency

SHORAD	Short Range Air Defense
SHTU	Simplified Handheld Terminal Unit
SICPS	Standard Integrated Command Post System
SIGINT	Signal Intelligence
SIMNET	Simulation Network
SINCGARS SIP	Single Channel Ground-Airborne Radio System
SITREP	Situation Report
SME	Subject Matter Expert
SOF	Special Operations Forces
STAARS	Standard Army After Action Review System
STAMIS	Standard Army Management Information System
STARLOS	SAR Target Recognition and Location System
STE	Simplified Test Equipment
STOW	Synthetic Theater of War
STOW-E	Synthetic Theater of War - Europe
STRAC	Standards in Training Commission
STAFFEX	Staff Exercise
STX	Situational Training Exercise
SUV	Subsurface Warfare
SYSCON	System Control System Improvement Program
T&E	Test & Evaluation
T&EO	Training and Evaluation Outline
TA	Target Acquisition
TAC CP	Tactical Command Post
TACCS	Tactical Army Combat Service Support Computer System
TACFIRE	Tactical Fire Direction System
TACP	Tactical Air Control Party
TACSAT	Tactical Satellite
TACSIM	Tactical Simulation
TADSS	Training Aids, Devices, Simulations and Simulators

TAI	Targeted Areas of Interest
TBD	To Be Determined
TBP	To Be Published
TC	Tank Commander
TCMD	Transportation Control Movement Document
TCP/IP	Transmission Control Protocol/Internet Protocol
TCU	Tactical Computer Unit
TDMA	Time Division Multiple Access
TEMO	Training, Exercises and Military Operations
TES	Tactical Engagement Simulation
TES	Threat Emitters and Sensors
TESS	Tactical Engagement Simulation System
TF	Task Force
TFOCA	Tactical Fiber Optic Cable
TFS	Training Feedback System
TFXXI	Task Force Twenty One
TGT	Tank Gunnery Training
THAAD	Theater High Altitude Air Defense
TI	Tactical Internet
TIS	Thermal Imaging System
TK	Tank
TLP	Troop-Leading Procedures
TM; tm	Team
TMA	Training Mission Area
TMD	Theater Missile Defense
TMM	Training Mix Model
TOC	Tactical Operations Center
TOE	Table of Organization and Equipment
TOW	Tube-launched, Optically tracked, Wire-guided
TPN	Tactical Packet Network
TRADOC	Training and Doctrine Command

TSOP	Tactical Standing Operating Procedures
TSP	Training Support Package
TTP	Tactics, Techniques, and Procedures
TWGS	Tank Weapons Gunnery System
UAAPU	Under Armor Auxiliary Power Unit
UAV	Unmanned Aerial Vehicle
UCOFT	Unit Conduct Of Fire Trainer
UDT	User Data Terminal
UHF	ultra high frequency
UJTL	Universal Joint Task List
UN	United Nations
US	United States
USACAC-TNG	United States Army Combined Arms Command - Training
USAF	United States Air Force
USATSC	United States Army Training Support Center
USW	Undersea Warfare
VCU	Video Control Unit
VEH	Vehicle
VFMED	Variable Format Message Entry Device
VHF	very high frequency
VHSIC	Very High Speed Integrated Circuit
VIICS	Vehicular Intra/Inter Communications System
VMF	Variable Message Format
VNR	VIICS Net Radio
WAM	Wide Area Munitions
WAN	Wide Area Network
WARSIM 2000	Warfighters' Simulation 2000
WIN	WARSIM Intelligence Module

WCS	Weapon Control Status
WIRLESS LAN	Wireless Local Area Network
WWW	Worldwide Web
XO	Executive Officer

Appendix B

Framework for Comparative Assessment

The framework discussed in this appendix was established to permit the comparative assessment of environments for collective training with respect to their feasibility, affordability, suitability and deployability. The framework is designed for use by material developers, training developers, and trainers to standardize and integrate their assessments of training approaches at different decision points associated with the development and procurement cycle for new combat equipment and related training facilities.

Because of the need to consider the feasibility, affordability, suitability, and deployability of each training environment simultaneously, a multi-attribute utility model was selected as the framework for assessing these characteristics of training environments, and summarizing the assessments to determine the relative appropriateness of the training environments. The model allows for considering the characteristics of the environments in detail, and permits the characteristics to be given different weights so that the importance of some may be emphasized in comparison to others.

The decision aid requires that if a question is answered for one environment, it must be answered for them all -- there is no "not applicable" rating. If a question does not seem relevant to a particular combat system or exercise, then the rating may be omitted for all of the environments.

Framing questions were generated to represent the aspects of each characteristic of the environment to be assessed. Considerable introductory material explaining each characteristic and each framing question is provided. The assessment scales generally provide a description of the condition associated with each rating level. Subsequent paragraphs in this section of the report discuss the framing questions for each of the characteristics in detail.

Feasibility

Feasibility asks whether there are any impediments to implementing a particular training environment. For example, certain resources might not be available (e.g., larger areas of training land), or a technical challenge might be too difficult in the time frame projected (e.g., realistic representations of a platoon of dismounted soldiers in a virtual environment), or there may be unacceptable risks associated with using the training environment (e.g., it interferes with commercial airspace). It is important to ask these questions early in the development of a training environment to determine whether further effort on that environment is warranted.

Clearly, any new training system will have some requirements that involve monetary costs. Feasibility focuses on the likely availability of components needed to create the training environment. As a practical matter, feasibility must incorporate a reasonable cap on costs. Otherwise, it might be relatively easy to claim that the needed resources would be available, by

assuming no cost constraints. Projected costs to provide a particular environment that are too high (e.g., costs to purchase new land, costs to field a simulator suite in which an entire battalion can be trained), call into question the further exploration of that environment. Any aspect of the training environment that seems likely to be "unavailable at any price" makes that environment infeasible. Any aspect of the training environment that seems "possible only at prohibitive cost" also makes that environment infeasible within the cost constraint.

Feasibility and affordability are the characteristics that are most likely to determine whether a particular environment is a viable alternative. If some aspect of the training environment is feasible, but raises concerns about cost, the user could rate the appropriate questions in the affordability section while these concerns are fresh in mind.

Feasibility is addressed in three broad questions: The first concerns the risk that required technologies will not be developed in time; the second concerns the risk that physical resources (land, facilities) cannot be made available within the cost constraints; and the third concerns other risks of establishing and operating the proposed environment. A rating of zero or one on any of these questions should be regarded as sufficient to stop further evaluation of the proposed environment until the feasibility question is addressed successfully.

The training environment will be expected to train specific missions, functions, and tasks. An important question is whether the technology required to create the environment that will satisfy those expectations will be available in time, and within cost constraints.

For the constructive, virtual, and hybrid environments, the technology risks are in the sophistication of the hardware and software needed to create an environment (or link environments) so that all the required missions, functions, and tasks can be trained. To the extent that the environment relies on technologies that are only concepts or have been demonstrated, but do not yet have commercial, off-the-shelf availability, the risk is high.

There are also risks associated with live environment technologies. New weapons may have capabilities that will be difficult to simulate. Targets must be able to simulate the future threat signatures in all spectra. New C4I systems may increase information flow in ways that will be difficult to capture, making it difficult to provide feedback about the commander's perspective and judgement.

1. Technology risk: Will the needed technologies be developed within the time and cost parameters?

Rating	Description
5	There is no risk involved in developing this environment. Hardware and software available off-the-shelf will meet all needs.
4	
3	There is some risk that needed technology will not be available to implement the environment. Technology has been demonstrated, but is not available off-the-shelf.
2	
1	
0	There is considerable risk that needed technology will not be available to implement the environment. Technology has yet to be demonstrated.

The second question concerns the availability of land and facilities. Land is related to the ability to build live environments that are capable of training the echelon in the missions, functions, and tasks associated with a particular exercise. The new weapons and equipment available to the force may require enlargement of training areas or ranges, or reconfiguration within existing space. The risk to feasibility is that the land is not available, or cannot be obtained or reconfigured on time, where it is needed (e.g., at home stations), and within cost constraints.

For the constructive, virtual, and hybrid environments, the availability of facilities is a risk factor. If new buildings must be constructed, or large numbers of hardware items need to be purchased and provided to units, then there is a risk that these will not be available within the cost constraints.

2. Resource risks: Will land and facilities be available, where they are needed, within the general cost constraint?

Rating	Description
5	There is no risk involved in developing this environment.
4	
3	There is some risk that resources will not be available
2	
1	
0	There is considerable risk that resources will not be available.

Finally, implementing the environment and operating it at the tempo required to achieve the training objectives may entail other risks: e.g., concerns about land use, threats to plant and animal species, water pollution, intrusion into civilian airspace (especially if new land must be acquired), or consequences for civilians of use of certain electronic spectra (e.g., jamming airport radars or civilian broadcast bands). The following question requires careful consideration of the effects of using the environment. Generally, the live environment would be most likely to entail these risks.

3. Are there other risks associated with implementing and operating the environment?

Rating	Description
5	There is no risk involved in implementing and operating this environment.
4	
3	There is some risk that implementing and operating the environment will cause unacceptable damage or disruption.
2	
1	
0	There is considerable risk that implementing and operating the environment will cause unacceptable damage or disruption.

Affordability

The purpose of the questions in this section is to address in overview some of the costs that may be incurred in developing and deploying a training environment in a way that can be useful at early stages of development. There are many approaches to the analysis of costs, cost effectiveness, and cost-benefits. Simpson (1995) concludes that the Department of Defense has not defined cost-effectiveness methods adequately. He feels that the cost aspects are relatively well defined, but the effectiveness analysis methods are not well developed. As the training environment becomes more clearly defined, the more precise cost analysis methods documented, for example, in DoD acquisition management policies and procedures (DoD, 1991) can be used. Simpson (1995) gives the following list derived from Knapp and Orlansky's (1983) cost element structure. This should serve as an aid in determining what should be considered in answering the subsequent questions.

Cost Factors Associated With Phases of Development and Deployment

Research and Development

- Design
- Component development
- Producibility engineering and planning
- Tooling
- Prototype manufacturing
- Data
- Evaluate training programs, courses, devices
- System/project management
- Facilities
- Other

Initial Investment

- Production
- Engineering changes
- Purchase programs, courses, devices
- Common equipment

Data
Evaluate training programs, courses, devices
System/project management
Rents
Operational/site activation
Initial training
Transportation
Other

Operating and Support
Direct costs
Indirect costs

Research and Development

1. What will be the relative costs of design and development of the training environment?

Rating	Description
5	No changes are required, so there are no design or development costs.
4	The changes to existing environments are easy to design and develop.
3	The changes to existing environments are a moderate technical challenge and should incur modest costs to design and develop.
2	Some changes to the existing environment are technically challenging, requiring moderate research and development costs.
1	Changes to existing environments are a serious technical challenge requiring substantial research and development costs.
0	New environments must be developed from scratch.

Acquisition

2. What will be the *relative* costs of purchase or improvements to land or buildings required for this exercise in this environment?

Rating	Description
5	Land and buildings needed will be obtained at no cost.
4	Land and buildings needed will be inexpensive.
3	Land and buildings needed will be moderately expensive.
2	Land and buildings needed will be expensive.
1	Land and buildings needed will be very expensive.
0	Land and buildings needed will be prohibitively expensive.

3. Will needed equipment and systems (e.g., computers) available from commercial, off-the-shelf (COTS) inventories? (In particular, a high rating should be given if the computational needs may be met throughout the Common Hardware/Software program (Association of the U.S. Army, 1996, p.271). Some systems may rely on innovative hardware/software developments,

and while these should not be discouraged out-of-hand, they do raise questions about costs. A low rating on this item should not be an automatic disqualification, but should definitely raise concerns. Any system identified in the feasibility section as a moderate to high technical challenge probably requires added scrutiny with respect to costs.

Rating	Description
5	Yes.
4	
3	
2	
1	
0	No.

4. Will embedded training systems be used to implement (all or part of) the training environment? Receiving a low rating on this question should not lead to automatic disqualification. If embedding is not perceived as a cost-saving factor for a particular system, then it should be given a low weight.

Rating	Description
5	Fully integrated with real equipment (dual use). Lowest cost implication.
4	Integrated, but not dual use. Small cost implication.
3	Attached. Moderate cost to acquire attachments.
2	Umbilical. Somewhat costly to acquire systems that plug into actual equipment.
1	Embedded components are a minor part of the simulation environment. Very few cost savings likely.
0	No embedded components. No cost savings.

5. What will be the *relative* costs for the initial operational configuration of software (programs and databases) for performing this exercise in this training environment? Costs for software are liable to be higher for virtual, constructive, and hybrid environments.

Rating	Description
5	No modifications to existing software are needed. No software costs.
4	Most of the existing software will be reused. Low software costs.
3	Modifications required are a low technical challenge. Moderate cost.
2	Modifications are extensive or moderately challenging. Expensive.
1	The system is new and complex and will be a technical challenge. Very expensive.
0	The system requires innovative computational techniques. Very expensive and risky.

6. What will be the relative costs for the initial training support packages (TSPs) for performing this exercise in this environment?

Rating	Description
5	No modifications to existing TSPs are needed. No additional costs.
4	
3	Modifications required to existing TSPs are not extensive. Moderate costs.
2	
1	Modifications required to existing TSPs will be extensive. Expensive.
0	Entirely new TSPs will have to be developed for this exercise. Very expensive.

Maintenance and Upgrades

7. Programmed upgrades over the life-cycle span of use (see related sections under Feasibility for definitions of the terms in the table):

Upgrade to:	High Cost					Low Cost
Training Ammunition	0	1	2	3	4	5
Targetry	0	1	2	3	4	5
TES	0	1	2	3	4	5
Training Instrumentation	0	1	2	3	4	5
Land and buildings	0	1	2	3	4	5
Other	0	1	2	3	4	5

8. Costs of upkeep: Annual costs of expert personnel to replace worn or broken components of training environment; costs of spare/replacement parts; costs of personnel, equipment, and supplies to provide routine maintenance and housekeeping. (If embedded training systems that are integrated into the real equipment are used, count replacement of the embedded training system end items here.)

Rating	Description
5	Low cost.
4	
3	
2	
1	
0	High cost.

Operations

Operations costs are for the implementation of one exercise, including all missions and re-runs typically needed.

9. Costs for personnel to set-up, control, operate, and clean up training environment.

Rating	Description
5	Low cost.
4	
3	
2	
1	
0	High cost.

10. Costs of expendables (electric power, ammunition, devices, spare parts, and fuel used on used in the selected training environment) for this exercise.

	High Cost					Low Cost
Ammunition	0	1	2	3	4	5
Devices	0	1	2	3	4	5
Spare parts	0	1	2	3	4	5
Fuel	0	1	2	3	4	5
Electric power	0	1	2	3	4	5

The following four questions concern other cost-related factors that may influence the choice of training environments. It is probably very difficult to determine exact costs for these aspects of training environments, but the concerns should be raised. Low scores are not "show stoppers". The first question attempts to quantify the possibility of using training time more effectively in certain environments. The next two have to do with accommodation of past and future systems. The last question deals with the capability to connect the environment for a given exercise to other training environments to create a hybrid environment.

11. Relative efficiency. The purpose of this question is to examine whether the proposed environments offer the possibility of more efficient use of unit training time. The live environment should be considered to be the baseline and given a rating of 1. The other environments should be rated using the scale provided, which indicates the number of events (one event = conduct a mission, task, or process, conduct the AAR, and reset for the next one) that can be conducted in the same time that one such event is conducted in the live environment.

Rating	Description
5	More than three* events can be run in the proposed virtual or constructive environment for each event run in the live environment.
4	About three events can be run in the proposed virtual or constructive environment for each event run in the live environment.
3	About two events can be run in the proposed virtual or constructive environment for each event run in the live environment.
2	About three events can be run in the proposed virtual or constructive environment for every two events run in the live environment.
1	One event can be run in the proposed virtual or constructive environment for every event run in the live environment.
0	Fewer than one complete event can be run in the proposed virtual or constructive environment for every event run in the live environment.

*The numbers of events are rough rules of thumb. They may be modified, as desired. The weight applied to this rating can be increased to give more emphasis to this aspect, if desired.

12. Impact on legacy systems. The proposed environment may involve modification of an existing environment, or substitution of a new environment for the old one. In either case, there will be consequences for using the modified environment to train legacy systems. For example, replacing the UCOFT with the AGTS will have consequences for summer training of Army National Guard units that have not received new tanks. The implication of a low rating on this aspect is that additional costs may be incurred by some units to maintain two systems in parallel.

What will be the impact of reconfiguring the proposed training environment(s) on training the use of legacy systems (older combat systems) that require the current configuration of the environment for training)?

Rating	Description
5	Reconfiguration of existing training environment will not impact training with legacy systems. (There will be no such systems, or legacy systems will be able to use reconfigured environment.)
4	Reconfiguration of existing training environment will have negligible effects on training with legacy systems.
3	Environment can be reconfigured on demand to suit new or legacy systems.
2	Reconfiguration of existing training environment is permanent and will have moderate effects on training with legacy systems.
1	Reconfiguration of existing training environment is permanent and will have severe impact on training with legacy systems.
0	Training with legacy systems will not be suitable in the reconfigured environment.

Future systems. This question is more difficult to answer precisely because the parameters of the future systems may not be clear. On the other hand, at least one example of a training environment is designed to provide wide flexibility in accommodating alternative equipment, possibly including some future systems (Aviation Reconfigurable Manned Simulator, or ARMS).

13. To what extent will the proposed environment support the next generation systems used at this echelon in this type of exercise?

Rating	Description
5	Environment should support all next generation systems.
4	Environment will support most next generation systems.
3	Environment will support many next generation systems.
2	There are key next generation systems the environment will not support fully.
1	Environment will partially support only a few next generation systems.
0	The environment will not support training the next generation systems.

Creating hybrid systems. In order to create opportunities for hybrid exercises in which soldiers training in different environments are operating on the same synthetic battlespace, it must be possible to link systems in each environment so that position/location, weapon firing events, and weapon effects are properly represented in each environment. The Army is moving toward a Common Operating Environment (COE) and has established a Distributed Interactive Simulation (DIS) environment, and a High Level Architecture (HLA) for linking different environments.

14. Can the elements (e.g., weapons platforms) and actions (e.g., maneuver and weapons effects) of the echelon training in this environment be represented accurately in other environments? (Do not answer this question for individual qualifications, crew gunnery qualification tables, CALFEX, STX, or STAFFEX.)

Rating	Description
5	This capability is designed into this environment.
4	Adding this capability to the environment is a low technical challenge.
3	Adding this capability to the environment is a moderate technical challenge
2	Adding this capability to the environment is a difficult technical challenge.
1	Adding this capability to the environment is a very difficult technical challenge.
0	Adding this capability to the environment will be technically infeasible.

Suitability

The method discussed here involves rating the environment for its face validity with respect to training the desired tasks. This method, which is a version of the Task Performance Support (TPS) Codes, may be applied when the environment is in various stages of development (SHERIKON, 1995, pp. 17-19 illustrates this application). This method appears to be the only applicable solution for assessing environments in the abstract, rather than particular instantiations of them.

In the previous application of TPS Codes (SHERIKON, 1995) the ratings of one environment were conducted with respect to specific tasks identified in Army training publications (specifically, ARTEP MTPs). Each step required to perform a task was identified, and performance measures were identified for each step. Then, Army SMEs were asked to rate the degree to which the environment (Close Combat Tactical Trainer, CCTT) could support performance to those standards. Aggregates of the ratings for each step are then produced (using decision rules, rather than numerical averages) to provide a measure of the degree to which the environment supports training the task.

In the present application, dealing with some combat systems that are in early stages of development, it is difficult to be certain that the tasks in the present ARTEP MTPs will remain valid. In particular, the steps identified and the associated performance measures might change. It is more convenient to assume that the general functions performed by the individual and unit will remain unchanged. These functions are defined, for our purposes, by the tactical level AUTL (Army Universal Task List) task areas, called ARTs (for Army Tactical).

Within this functional approach, it is useful to distinguish between tasks that involve psychomotor performance and those that involve cognitive performance. Generally speaking, this distinction is made with respect to both functional areas and echelons. When individuals, crews, and platoons, deploy and conduct maneuver, for example, they are actively engaged in perceptual and psychomotor tasks. The command and control functions that are exercised by commanders and leaders (especially at higher echelons) are more cognitive and perceptual.

ESELDA is structured to provide for separate ratings of support for cues and responses within two types of tasks: those focused on psychomotor performance and those more involved with cognitive performance. For the individual and crew level training exercises, the ratings for cognitive performance cues and responses may be omitted. For exercises focused on training commanders and staffs in command and control, the psychomotor cues and responses may be omitted.

The next table provides some distinctions between the types of cues that may be needed to stimulate psychomotor and cognitive responses. Note that some cues in the environments may be in spectra that are not discernable by humans (infra-red, millimeter wave, bio-chemical, etc.). These cues, if available, are detected by instruments and translated into visible, auditory, or kinesthetic cues that humans can perceive. The rating should concern the degree to which the simulation represents the cues soldiers could receive through instruments and monitors they will carry in battle.

Types of Cues Associated With Psychomotor and Cognitive Performance

Psychomotor	**Cognitive**
Visual motion (variable view)	Visual motion (constant view)
Realistic representation: color/ texture/ shape/ 3-D/ perspective	Iconic representation of situation: color or shape encoding/ 2-D
Audio (Voice)	Audio (Voice)
Audio (Ambient)	Writing/ Drawing
Kinesthetic (physical motion, inertia or resistance of equipment)	

In the application of TPS Codes (SHERIKON, 1995) the cues and responses were judged against a field training baseline: The highest rating of support for a particular performance measure is obtained if, "Sufficient cues are present within the simulation environment and appropriate responses are supported such that the training experience is much the same as it is in a field environment." (SHERIKON, 1995, p.12) In the present application the field environment is not assumed to be satisfactory *a priori*. Each environment must be rated independently with respect to providing appropriate cues and permitting appropriate responses.

Live environments will typically support some actions to a greater degree than will virtual environments. For example, in live environments soldiers would put up real camouflage,

or dig real defensive positions. Virtual environments will typically not support those actions. (The capacity of the synthetic environment to show the result of those actions -- show camouflage or vehicles in defilade -- should be considered in rating the environment for providing appropriate cues.) For psychomotor and procedural tasks, it is very important that the environment provide the opportunity to carry out the actions. For cognitive tasks, it is important that the environment permit the selection of the appropriate response. Virtual environments will probably support procedural tasks and important psychomotor tasks. Constructive environments will not support psychomotor tasks, but for cognitive tasks (and some procedural tasks), such environments may be quite suitable.

1. Will the environment provide cues needed to trigger psychomotor responses in trainees?

Rating	Description
5	Appropriate, realistic visual, audio, and kinesthetic cues are provided.
4	Most of the needed cues are provided; missing cues do not cause negative training.
3	Many of the needed cues are provided; missing cues do not cause negative training. Some subtasks may not be supported due to these limitations.
2	The cues are limited, they are only appropriate for part of the overall task.
1	The cues are severely limited or unrealistic.
0	The environment does not provide appropriate cues.

2. Will the man-machine interface permit trainees to make (act out) all psychomotor types of response?

Rating	Description
5	Trainees are using the actual equipment, using those systems to respond.
4	Trainees are using a mock-up that permits appropriate responses.
3	Trainees are using a mock-up that permits appropriate responses in most situations. Responses appropriate for some subtasks or conditions are not supported.
2	Trainees are using a mock-up (or real equipment that has been disabled) that only permits some responses (part-task trainer).
1	Responses are in a different modality than they would be in battle (e.g., trainee states response, rather than acts it).
0	Responses are not supported (e.g., trainee is passive).

3. Will the environment provide the range of cues, at an appropriate pace, needed to trigger cognitive processes in trainees?

Rating	Description
5	Appropriate visual, audio, written, and graphic cues (e.g., orders) are provided.
4	Most of the needed cues are provided; missing cues do not cause negative training.
3	Many of the needed cues are provided; missing cues do not cause negative training. Some tasks or conditions may not be supported due to these limitations.
2	The cues are limited, they are only appropriate for part of the overall task, or some of the conditions under which the task must be performed.
1	The cues are severely limited or unrealistic.
0	The environment does not provide appropriate cues.

4. Will the man-machine interface in the training environment permit trainees to demonstrate *selection* of tactically appropriate actions?

Rating	Description
5	Trainees are using actual equipment, all appropriate actions may be selected.
4	Trainees are using a mock-up that permits selection of all appropriate actions.
3	Trainees are using a mock-up that permits selection of appropriate responses in most situations. Actions appropriate for some subtasks or conditions are not supported.
2	Selections are demonstrated in a different modality than they would be in battle (e.g., trainee states preferred action, as in a test format).
1	
0	Selection of actions is not supported (i.e., trainee is passive).

<u>Stress</u>

Another aspect of performance involves the effects of stress. While simulated training environments are unlikely to create the same emotions as real combat (e.g., shock, horror, revulsion), they may incorporate various stress factors that will have psychological consequences (e.g., the real dangers associated with live fire; enemy surprises; rapid pace; continuous operations; complex operations). In some degree, the training given to soldiers and leaders is intended to enable them to function more effectively when they are under stress. The next questions in this section deal with the ability of the environments to produce or manipulate such stress factors as danger/risk, pace, and complexity.

5. Will the environment involve real dangers or induce a sense of danger?

Rating	Description
5	The environment involves actual moving combat vehicles and live ordnance.
4	The environment involves a few actual combat vehicles and live ordnance in a very controlled setting (qualification run, e.g.).
3	The environment involves actual moving combat vehicles.
2	The environment induces a sense of danger, without actual risk.
1	The environment induces a sense of competition; without actual risks.
0	The environment does not induce a sense of danger, nor does it involve real risks.

6. Will the environment permit variations in pace to stress (or relax) both physical and mental (decision making) performance? Assume that the pace for a qualification-type exercise is set at an appropriate level, so this item should not be rated for such exercises.

Rating	Description
5	Pace can be adjusted to stress (or relax) physical and mental performance.
4	
3	Pace can be adjusted, but the extremes are not very different.
2	
1	
0	Pace cannot be adjusted -- the exercise is under time control.

7. Variety of missions supported. The environment should be capable of supporting the variety of missions that the unit is likely to perform in this type of exercise, across a range of METT-TC conditions. The primary source document for missions applicable to the unit is the unit Mission Training Plan (MTP). The MTP also describes the types of conditions that might apply to execution of specific tasks (varying the conditions is addressed in the next question). However, emerging doctrine (accorded greater importance in the post-Soviet threat environment) covers additional missions such as peace-keeping operations (PKO) and operations other than war (OOTW), which should be considered, as well. Any other projected changes in the nature of missions that might be trained at this echelon, in this type of exercise, should also be considered. Only rate for echelons of platoon and higher. Do not rate for qualification exercises.

Rating	Description
5	The environment supports all missions in the unit/echelon MTP, as well as PKO and OOTW missions, and other missions anticipated in the future.
4	The environment supports all missions in the unit/echelon MTP.
3	The environment supports the most likely missions in the unit/echelon MTP.
2	The environment supports some of the most likely missions in the unit/echelon MTP.
1	The environment supports only one mission in the unit/echelon MTP.
0	The environment supports only part of one mission.

8. Will the environment permit manipulation of enemy forces, terrain, weather, friendly troops, time, and civilian considerations to make missions more or less complex? Assume that the complexity for individual, crew, and platoon qualification exercises is set at an appropriate level, so this item should not be rated for such exercises.

Rating	Description
5	Complexity can be varied over a wide range.
4	
3	Complexity can be varied over a narrow range.
2	
1	
0	Complexity can not be varied at all -- scenarios are fixed.

9. Training mission planning and preparation. The commander and staff must be able to visualize the terrain and (known or assumed) enemy forces in order to develop and assess courses of action (COAs) as part of the overall decision making process (DMP). The environment should allow considerable variation in METT-TC factors to provide a variety of training experiences so that commanders and staffs can develop good tactical judgement. Feedback contrasting the plan developed with a representative successful plan should be available for a range of configurations of METT-TC factors. Qualification tables should not be rated.

Rating	Description
5	The environment supports variation in terrain and (known or assumed) enemy forces to develop planning scenarios; and there is support for feedback contrasting the developed plan with a representative successful plan.
4	
3	The environment provides a limited set of "canned" scenarios as the basis for planning exercises, but these are supported by representative successful plans.
2	
1	
0	Planning is not supported in this environment, it must be done outside the environment.

10. Training mission rehearsal. Rehearsals allow each leader to demonstrate understanding of the actions his/her unit is to take. They permit the commander and staff to recognize problems in synchronization of actions, or that their plan does not have an appropriate branch and sequel for a particular enemy course of action. Rehearsals should allow the same variation in terrain and mission conditions allowed in the environment for training planning tasks (see question 9). Qualification tables should not be rated on this aspect of suitability.

Rating	Description
5	Environment supports variation METT-TC conditions to develop scenarios to support rehearsal training. All appropriate personnel may participate in rehearsal. Enemy COA(s) are represented in the simulation. Time may be accelerated, but sequencing and synchronization requirements of the OPORD and doctrinal timing factors are enforced.
4	
3	There are a variety of canned scenarios representing METT-TC variation. Some elements of the training audience do not participate (their actions are simulated). Enemy COAs may be represented nominally (e.g., someone places icons to represent them). Some actions are "checked off," with moderate regard for doctrinal timing factors or sequencing and synchronization required by the OPORD.
2	
1	
0	There are only a few canned scenarios. Some of the appropriate personnel are excluded, and their actions are not represented in the simulation. Enemy COAs are discussed, but not represented in the simulation. No variation of terrain or threat forces is possible. Actions are "checked off" with little regard to doctrinal timing factors or sequencing or synchronization required by the OPORD.

Feedback

Feedback on performance is critical to improvement over time. Two types of feedback are examined: real-time and post-training. Real-time feedback can be intrinsic (the trainee observes changes in the synthetic environment related to his/her performance), or extrinsic (an agent not participating in the environment, e.g., a coach, comments on performance). Glaser and Cooley (1973) note that intrinsic feedback is highly motivating. Post-training feedback is extrinsic in nature -- the environment is no longer subject to manipulation by the participants. The ratings given earlier to targetry, tactical engagement systems, and training instrumentation systems may help to determine whether the environment has the capacity to provide appropriate feedback. An environment that scores zero or one on questions 8, 9, and 10 is not likely to be useful for training.

11. Will the environment provide real-time, intrinsic feedback on performance of the tasks -- indicate what resulted from the participant actions? (Note that the time scale for "real-time" feedback is different for commanders compared to soldiers firing weapons. The environment must react quickly do provide real-time feedback for the latter, but the effects of a commander's orders will normally take some time to be realized in the training environment, as they would in a real battle).

Rating	Description
5	Actions by the lowest-echelon participant in the simulation result in real-time effects in the simulation environment that are consistent with the participant's actions.
4	Actions are mediated through a system that introduces a small delay in response. This delay does not cause negative training.
3	Some feedback that would occur in real combat is not reproduced in the simulation (e.g., near misses are not indicated, or difficult to observe compared to real combat).
2	Actions are mediated through a system that introduces delays large enough to cause negative training.
1	Feedback is provided by some other mechanism than effects in the synthetic environment (e.g., sound or voice announces result of action).
0	The environment is not modified by participant actions.

12. Will the environment provide for real-time, extrinsic feedback on performance of the tasks, i.e., coaching or mentoring?

Rating	Description
5	A coach or mentor will have sufficient visibility of the actions of participants to provide appropriate feedback.
4	
3	A coach or mentor will have limited visibility of the actions of participants being trained, reducing his/her ability to provide feedback on all aspects of performance.
2	
1	
0	Coaching participants in this exercise is not possible in this environment.

13. Will the environment provide for gathering data to permit AAR-type feedback on performance (battle damage assessments; objective summaries of tactical strengths and weaknesses; guidance about areas to emphasize in subsequent training)?

Rating	Description
5	Sufficient information is captured to permit objective review of performance, development of training guidance.
4	Most elements of information that should be available to prepare an objective review are gathered.
3	Many elements of information that should be available to prepare an objective review are gathered.
2	Only a few elements of information are gathered, focused on a subset of all the tasks to be trained.
1	Observers or other personnel are required to gather the information needed for a performance review.
0	No provision is made for this environment to support AAR type feedback.

The previous questions are focused primarily on aspects of the environments with respect to training the execution of tactical tasks. Company/teams and higher echelons also perform planning and rehearsal tasks. The following questions are focused on the suitability of the environments for training planning and rehearsal tasks. They should only be rated for echelons at or above company/team.

Support for Different Approaches to Part-Task Training

One approach to instructional design is to partition tasks into components, then train the component parts prior to training the whole task. The different training environments may support part-task training to different degrees, and this may depend upon the approach taken to partition, and reassemble, the tasks. Naylor (1962) identified three approaches to partitioning:

- Simplification: some task characteristics (e.g., time requirements) are relaxed to make it easier to perform the task. As performance improves, the requirements are re-imposed. The crawl-walk-run training methodology is an example of this approach.

- Fractionation: different types of part-tasks (e.g., procedures; perceptual-motor sub-tasks) are trained separately (even though they may be performed simultaneously in the whole task).

- Segmentation: the task is divided along temporal or spatial dimensions (e.g., sub-tasks are identified as steps in a sequence; or, different groups of personnel perform different sub-tasks). This approach was used to develop training in decision making for specific sub-groups of the brigade staff (Graves, Campbell, Deter, in preparation).

Naylor (1962) also identified three methods for reintegrating the part-tasks identified through fractionation or segmentation:

- Pure: practice each part, then put them all together at once.

- Progressive: practice two parts separately (A, B), practice them together (AB), practice a third part (C), then practice them all together (ABC).

- Repetitive: practice A, then AB, then ABC. A variation, called reverse repetitive, or backward-chaining, is to practice in the order C, BC, ABC. The two methods emphasize specific tasks and linkages to different degrees.

A training environment might support one or more of these methods of partitioning tasks and reintegrating them. The training developer has to decide which of these approaches should be used in developing training programs and determine whether the training environment will support that approach. Generally, the virtual and constructive environments are somewhat more flexible in allowing partitioning. The live environment may require performance of tasks unrelated to the desired focus of training. Exercises that are designed to demonstrate proficiency should be about whole task performance, so qualifications should not be rated on this aspect of suitability.

14. Does the environment support the desired approach to task partitioning (simplification, fractionation, segmentation)? (Qualification exercises should not be rated on this aspect.)

Rating	Description
5	Yes
4	
3	
2	
1	
0	No

Deployability

The ability to sustain forces for indefinite periods in regions that are not previously equipped to support training places a premium on the deployability of the training environment. Two aspects of deployability are considered: The logistic burden and the requirements for support of the environment, when deployed.

1. Logistic burden. The weight or volume requirements of the TADSS required for the particular training environment may impose logistic burdens. Some equipment may be of specific dimensions, or weight, that will require special transportation arrangements. Or, special transportation may be required because the equipment is fragile under transport.

Rating	Description
5	Embedded training system provides training environment, there is little to deploy in addition to the equipment itself.
4	Pre-positioned training environment and equipment is available, there is little to deploy for training purposes.
3	Training systems are a small logistic burden (e.g., attached or umbilical types of embedded systems; training ammo).
2	Additional equipment or materiel to be deployed pose moderate logistic problems.
1	Additional equipment or materiel to be deployed pose severe logistic problems.
0	It is not possible to deploy the environment; a new environment must be constructed at the new location.

2. TADSS operating requirements. The training environment may require special operating conditions when deployed (e.g., air conditioning, dust suppression). There may be special power requirements that cannot be met by the MTO&E equipment of the unit itself, or by the region in which the training environment is deployed. Some equipment may wear out faster in the deployed location. In performing this rating assume that units smaller than a battalion/task force have access to the generators and other equipment of higher echelons.

Rating	Description
5	The environment has no special operational requirements that cannot be met by the higher echelons.
4	
3	The environment either has special operational requirements necessitating modifications to its facilities, or certain equipment is consumed more rapidly, or it needs additional power beyond that available from the unit.
2	
1	
0	The environment can only be supported in its existing location.

The following pages show a blank spreadsheet that can be used to input ESELDA ratings. The weights are initially set so that all aspects are equally weighted (weight = 1). Some practitioners believe that the aspects should be rank ordered and the weights assigned by giving a large weight (say 10) to the most important aspect, then assigning weights in descending order (ties permitted). The lowest weight should represent the relative weight to be given to the least important aspect when compared to the most important (i.e., the least important aspect might be given a weight of 3 compared to the weight of 10 assigned to the most important). Some users believe that the weights should be standardized so that they sum to 1.00. This can be accomplished by dividing each weight by the sum of all weights.

The range audit column is a way to examine the variation in scores and weighted scores assigned to the different environments. This helps to locate those aspects that contribute to differentiating among the environments -- higher ranges mean greater variation in the ratings. If the range is zero, then that aspect does not contribute to differentiating among environments.

Echelon:	**Exercise:**												
Systems:													
ART:			**Live/FoF**		**Virtual**		**Constructive**		**Hybrid**			**Range Audit**	
Battlefield functions:		Weight	Rating	WxR	Rating	WxR	Rating	WxR	Rating	WxR		Range	WxRange
Feasibility													
	1. Technology risk	1											
	2. Resource availability risk	1											
	3. Operational risks	1											
Feasibility Subtotal													
				Live/FoF		**Virtual**		**Constructive**		**Hybrid**			
Affordability													
	1. Costs of research and development	1											
	2. Costs of land/buildings	1											
	3. COTS availability of equip./systems	1											
	4. Use of embedded systems	1											
	5. Cost of initial software configuration	1											
	6. Cost of training support packages	1											
	7. Programmed upgrades over life-cycle:												
	Training Ammunition	1											
	Targetry	1											
	TES	1											
	Training Instrumentation	1											
	Land, buildings, facilities	1											
	Other	1											
	8. Upkeep (replace broken parts, etc)	1											
	9. Cost of personnel to operate	1											

Echelon:			Exercise:												
Systems:															
ART:					Live/FoF		Virtual		Constructive		Hybrid			Range Audit	
Battlefield functions:				Weight	Rating	WxR	Rating	WxR	Rating	WxR	Rating	WxR		Range	WxRange
	10. Cost of expendable items.														
		Ammunition		1											
		Devices		1											
		Spare parts		1											
		Fuel		1											
		Electric Power		1											
	11. Relative efficiency			1											
	12. Impact on legacy systems			1											
	13. Support for next-generation systems			1											
	14. Supports links to hybrid systems			1											
Affordability subtotal															
						Live/FoF		Virtual		Constructive		Hybrid			
Suitability															
	1. Psychomotor tasks: cues			1											
	2. Psychomotor tasks: responses			1											
	3. Cognitive tasks: cues			1											
	4. Cognitive tasks: appropriate actions			1											
	5. Stress: real dangers			1											
	6. Stress: pace			1											
	7. Variety of missions supported			1											
	8. Variable conditions			1											

blank

Echelon:		**Exercise:**											
Systems:													
ART:			**Live/FoF**		**Virtual**		**Constructive**		**Hybrid**			**Range Audit**	
Battlefield functions:		Weight	Rating	WxR	Rating	WxR	Rating	WxR	Rating	WxR		Range	WxRange
	9. Trains mission planning	1											
	10. Trains mission rehearsal	1											
	11. Feedback: real-time, intrinsic	1											
	12. Feedback: real-time, extrinsic	1											
	13. Feedback: AAR	1											
	14. Support for part-task training	1											
Suitability subtotal				**0**		**0**		**0**		**0**			
				Live/FoF		**Virtual**		**Constructive**		**Hybrid**			
Deployability													
	1. Logistic burden	1											
	2. Operating requirements	1											
Deployability subtotal													
				Live/FoF		**Virtual**		**Constructive**		**Hybrid**			
Total Weighted Rating:													
				Live/FoF		**Virtual**		**Constructive**		**Hybrid**			

blank

Appendix C

Future Combat Systems and Equipment

This appendix discusses trends in technology and combat system capabilities that will impact Army units in the future. The information was used to provide background material for the study. This appendix has two sections:

- A description of the capabilities and trends in technology expected to impact on Army equipment capabilities between the years 2000 and 2020. This information was compiled from multiple sources consisting of both defense and industry publications. The DOD Military Critical Technology List was the primary document used.

- Descriptions of sixty-nine future systems that represent emerging technology. These were extracted from the Army Modernization Plan and the Army Science and Technology Master Plan. Many of the descriptions are from a data collection effort for a STRICOM Long Range Planning Study.

This appendix offers a view into the training challenges of the future. Some of the systems described will be fielded as division and corps assets, but most will have their greatest impact on the capability and training of brigade combat teams (BCT). The systems found in the BCT represent the Army's largest investment in training simulations and simulators. Primary documents used to develop this descriptive listing were:

- Operational Concept Requirements (Most are draft documents).
- System Training Plans (Most are draft documents).
- Army Science and Technology Master Plan (1997).
- Army Modernization Plan (1997).
- Joint Warfighting Science and Technology Plan (1996).
- Army Green Book (1997-98).

Section One:

Capability and Technology Trends

The capability or trends in technology that will be dominant between the years 2000 and 2020 are summarized as follows:

Area	Trend	Technology
Vehicles	• High mobility. • Reduced signature. • Increased range. • Increased payload. • Small size.	• Vehicle Electronics Systems (Vetronics) (The objective is to reduce the workload of crews who managing high volumes of data. Flat panel displays are critical.) • Advanced diesel engines that are smaller with more power and low heat rejection. • Automatic transmissions with integrated braking and regenerative steering.
Information Systems (C4I2)	• Computational capability. • Information processing. • Signal/noise screening. • Integrated systems. • Seamless interfaces. • Information warfare.	• High performance computing. • Human system interface. • Information security. • Intelligent systems. • Models and simulations. • Networks and switching. • Signal processing. • Software. • Transmission systems.
Sensors and Lasers	• Improved sensitivity. • Improved information management. • Improved accuracy. • Improved	• Acoustic sensors for air and terrestrial platforms (Passive detection / location of personnel, weapons, and vehicles on land). • Platform noise

	discrimination criteria. • Interface reduction. • Data fusion. • Greater resolution. • Selective information processing. • Increased use of sensors, and lasers in future systems.	reduction. • Electro-optic sensors (Improvements in image intensification, target background contrast, and target resolution). • Magnetometers and magnetic gradiometers. • Countermeasures to defeat Threat lasers and sensors (Obscurants) (Scattering, absorption, distributing efficiency). • Radar (Millimeter wave, clutter reduction, greater resolution, power, and wide bandwidth). • Lasers (Tuneability, brightness, beam collimating, wavelength diversity).
Power Systems	• High energy efficiency. • Designed to resist/mitigate battle damage. • Interchangeable components. • Increased output per unit of input. • Increased compactness and reliability. • Lower cost.	• High-density conventional systems (Long life, graceful degradation, smaller volume/weight, high temperature, thermal management). • Mobile electric platform power (Simplicity, thermal management, energy extraction, power density, and permanent magnetic materials). • Pulsed and high power systems (Batteries, repetition rate, fault tolerance, solid state switches, capacitors, power distribution).
Armaments	• Increased lethality. • Smart (Sensor	• Case combustible. • Course corrected rounds.

	detection and automatic firing). • Integrated technologies. • Multiple weapons platforms.	• KE penetrators. • Tandem or multiple warheads. • Shaped charges. • Self-forging fragments. • Solid propellant. • High explosive formulations. • Highly reliable, fast setting, discriminating, high stability fuses. • Automatic loaders. • Systems integration. • Sensors. • Control software. • High fault tolerance. • Target acquisition tracking system.
Aeronautics	• Increased agility. • Stealth. • Lighter. • Miniaturized. • Increased combat survivability.	• High energy release protection. • Integration of engine control with flight control systems. • Gas turbine engine. • Human system interfaces. • Cooled blades and vanes.
Directed and KE systems	• Directed energy. • Non-sensitive propellants.	• High energy chemical laser.
Electronics	• Situational awareness. • Autonomous operations. • Computational capabilities.	• Radar. • Communications. • Navigation. • Guided munitions. • Sensors. • Electronic devices. • Size, speed, bandwidth, image processing, switching time, digitizing rate, transfer rate, stability.

Information Warfare	• Protection of assets. • Intrusion/ assessment. • Operational exploitation. • Disruption.	• Electronic protection. • Optical countermeasures. • Optical counter-countermeasures.
Weapons effects and countermeasures	• Hardening.	• Penetration suppression. • Shock suppression. • Energy absorption. • Fragmentation resistant materials.
Guidance and vehicle control	• Increased accuracy and control. • Precision strike. • Accurate maneuver control. • Hybridization.	• Flight control systems. • Accurate positioning, attitude, pointing, and controlling. • Accurate time and frequency. • Accurate velocity, motion, compensation, and positioning. • Inertial navigation systems. • Radio and data based referenced navigation systems.
Space	• Broad banded communications. • All weather intelligence. • Real time meteorology. • Information warfare systems. • Environmental monitoring. • 3-dimension navigation.	• Optronics (Directed energy optics, silicon optics, passively cooled optics). • Power and thermal management. • Sensors (IR spectral sensitivity).

Section Two

Overview of Selected Future Systems

This section briefly describes sixty-nine future systems that will have an impact on the Army between 2000 and 2020.

Abrams Tank Upgrade - The M1A2 tank is being fielded now; it represents a significant technological advance over the M1A1. The M1A2 makes extensive use of digital electronics and microprocessor control. The core electronic architecture of the system utilizes a high-speed data buss with a sophisticated system integration package for transmitting digital information and commands throughout the tank. Electronic sensors and systems improve driving, target identification, and information flow between the computer-driven subsystems, the crew, and other combat vehicles through the Inter-Vehicular Information System (IVIS). The commander, gunner, and driver have new displays. Lethality and fightability are improved with enhancements to target acquisition and fire control. The Commander's Independent Thermal Viewer (CITV) provides a 360-degree, all-weather, day-night, target surveillance system that allows the commander and gunner to act as a "hunter-killer" team. The commander searches for targets while the gunner engages different targets. When the gunner fires the weapon, the commander can then "hand-off" a new target to the gunner with the push of a button. This capability greatly enhances the potential lethality of the system and measurably improves the engagement speed of the tank. IVIS dramatically improves unit command and control in battle situations under all weather conditions. The IVIS processes key information at the commander's control through an integrated, gridded mapping system of the area of operations. The IVIS displays the locations of enemy and friendly vehicles and selected reports, and provides current status and diagnostics of key systems. IVIS is augmented by a Navigation (POS/NAV) system which displays vehicle position and heading references to both the commander and driver through the Commander's Integrated Display (CID) and Driver's Integrated Displays (DID). The CID reduces the commander's navigational tasks and greatly improves overall situational awareness. For the driver, the DID enables him to drive from point to point on the battlefield without constant direction from the commander. Improved crew stations and redundancies of electric processors enhance survivability. The gunner's sight includes azimuth stabilization. The dual-axis stabilization greatly enhances target acquisition and target tracking functions, especially while on the move. Supportability enhancements stem principally from the high commonality of components in the core electronics system. The extensive collection of Simplified Test Equipment (STE) required for the M1A1's on-vehicle diagnostics has been eliminated by built-in test and diagnostic capabilities.

The M1A2 Systems Enhancement Program (SEP) improvements focus on modifications to the computer core that are necessary to accept Army command and control software and operating standards, also known as the Common Operating Environment (COE). The most significant hardware improvements are the second-generation forward looking infrared radar (FLIR) in both sights, the Enhanced Position Locating Reporting System (EPLRS), a Global Positioning System (GPS) to enhance the positioning and navigation system, an integrated under-armor power/cooling system to mitigate power consumption and electronics heat,

enhanced memory and display components, and interfaces for the separately developed Battlefield Combat Identification System (BCIS) and Multi-Purpose Integrated Chemical Agent Detector (MICAD). The major objective for this program is to provide for the assimilation of future electronic upgrades, including the Army's objective digitized command and control software COE. The SEP program will set conditions for the acceptance of the Force XXI Battle Command Brigade and Below (FBCB2) software by incorporating better data processors, more memory capacity, better soldier-machine interfaces with adequate backup power, and cooling capability. The SEP allows for acceptance of that portion of the COE that affects inter-vehicle or inter-platform operations. The Under Armor Auxiliary Power Unit (UAAPU) is a key SEP component because of the power requirements of digitization. When the main engine is shut down, these new functions will require more power than can be sustained for long periods using vehicle batteries. The system can bleed air to the nuclear, biological and chemical (NBC) overpressure system and will reduce the main engine operating hours and associated high fuel consumption. This will yield savings in operating costs and will reduce engine wear and fuel consumption while increasing net operational range. It also provides power for the electronics cooling unit which reduces heat in the crew compartment, thus increasing electronic module reliability. The second-generation FLIR system enhances the capability and reliability of the M1A2 at night and during periods of reduced visibility. In addition to improved visibility, the SEP/second-generation FLIR will upgrade and replace current hardware and software. Most of the additional improvements involve more advanced technologies, such as: digital processing of the second-generation FLIR sensor data for advanced functions (auto target tracking, target recognition, cueing), embedded training, helmet-mounted heads-up displays, and an integrated combat protection systems designed to automatically counter incoming threat projectiles and missiles.

The next generation tank (Future Combat System) is not yet a program, but it is expected to have the following features:

- Increased survivability including an integrated vehicle defense sensor and countermeasures, signature management, advanced armor, active protection and lightweight structure.
- Advanced fire control including a 65% increase in target acquisition and 100% increase in rate of engagement.
- Advanced vehicle propulsion featuring an electric drive with active suspension, track and tensioner.
- Advanced cannon (electro-magnetic [EM]/electro-thermal-chemical [ETC]/liquid propellant [LP]) with crew automation (loading, tracking, sensor fusion).
- Embedded training, diagnostics, and technical help.

Advanced Antenna Prototype Subsystem (AAPS) - It provides on-the-move capability to receive intelligence information on demand. The antennas are mounted on a High Mobility Multipurpose Wheeled Vehicle (HMMWV) shelter and are linked to the Common Ground Station (CGS).

Advanced Cargo Transport (ACT) - This system will replace the CH-47 and the CH-53 helicopters. It will have increased payload (30 to 50%) and range. It will employ the battlefield identification system.

Advanced Quickfix - This system is an EH-60A Blackhawk equipped with Signal Intelligence (SIGINT) collection and intercept, emitter locating, and electronic countermeasures capabilities. It can detect, locate, collect, analyze, and exploit fixed frequency and Low Probability of Intercept (LPI) communications. It has a mix of sensors that include Communications Intelligence (COMMINT), Electronic Intelligence (ELINT), electronic attack and precision weapons targeting with internal cross-cueing. It interoperates with the Ground Based Common Sensor (GBCS) to provide range extension and greater accuracy. It provides deep fire support targeting beyond 100 km.

AH - 64 Apache Longbow - The Longbow Apache incorporates a millimeter wave radar air- to-ground targeting system that can operate during day or night, in adverse weather, and through battlefield obscurants. The Longbow Apache features a mast-mounted, millimeter wave, Fire Control Radar (FCR), a Radar Frequency Interferometer (RFI), and a radar frequency fire-and-forget Longbow Hellfire missile. The Longbow's digitized target acquisition system provides automatic target detection, location, classification, prioritization, and target hand over to other weapons platforms. The Longbow Apache is digitized to ensure rapid transfer of battlefield information gathered by the FCR. It can rapidly pass target data and troop disposition locations into air weapons, ground weapons, and intelligence assets to improve a commander's "view" of the battlefield. The Longbow Hellfire missile is a millimeter wave radar, fire-and-forget system. The FCR system sends target data to the Longbow Hellfire; the missile's millimeter wave radar seeker allows it to "fly" directly to the target without a laser designation requirement for the Hellfire. When Longbow Hellfire is launched it knows the target location and "seeks" the radar signature received from the FCR all the way to final impact. The fire-and-forget capability allows the helicopter to launch its missile and then immediately mask behind a terrain feature. The Longbow Hellfire has an improved all weather capability over the basic Hellfire, millimeter wave countermeasures for survivability, and an advanced warhead to defeat reactive armor.

Air Defense/Theater Missile Defense (TMD) Operations Center - The Air Defense/TMD Operations Center is a command and control, communications, and information center for theater battle management of air defense. It integrates and supports all TMD activities at the tactical, operational, and strategic levels for the theater. It integrates TMD radar operations and air defense weapons including the Patriot Advance Capability (PAC)-III, and the Theater High Altitude Air Defense (THAAD) system.

All Source Analysis System Upgrades - This is the intelligence and electronic node of the Army Battle Command System (ABCS). It uses decision support templates and predictive analysis techniques to provide timely information to commanders and other decision makers. It provides fusion of all source data, direct support to situation and target development, automated collection and asset management, and integration of weather and terrain support. It features direct communications connectivity to a wide variety of national and tactical sensors.

Autonomous Intelligent Submunition (Damocles) - It supports the next generation Search and Destroy Armor (SADARM) and is compatible with multiple carriers (Multiple Launch Rocket System [MLRS], Army Tactical Missile System [ATACMS], Tomahawk, and Joint Stand Off Weapon [JSOW]). It employs dual use sensor technology with a steerable ram air parachute, pivoting munitions to keep the target in view, and a steep look down angle for view over clutter.

Avenger - This air defense system will fire any Stinger missile and will use non-cooperative target recognition, second generation FLIR, Global Positioning System (GPS), and a mounted compass for passive detection and tracking, ranging, identification by aircraft type and hand-off. It incorporates an Infrared (IR) imaging seeker and will engage helicopters in clutter at extended ranges (2-3 times current range).

Bird Dog - This program uses existing platform technology to integrate a semi-automated Unmanned Aerial Vehicle (UAV) into the aviation attack team. The development of new platforms or sensors is not planned. This system will improve situational awareness for the aviation team and the maneuver commander. It features low acoustic, radar, and thermal signatures. It improves mission effectiveness and allows an increase to operations tempo. It will enhance survivability of manned reconnaissance and attack aircraft.

Bradley Fighting Vehicle (BFV) - The Bradley is a lightly armored, fully tracked vehicle that provides cross-country mobility, mounted firepower, and increased protection from artillery and small arms fire. This vehicle can provide direct fire support with great firepower. The BFV's improved speed and cross-country capability easily allow it to "keep pace" with the M1 Abrams tank in combat operations. The Bradley has recently been upgraded with a reactive armor, which provides improved survivability against anti-armor weapons. The M2A3 / M3A3 versions will be the next major modification. The improvements will include an improved laser range finder, a global positioning system with compass, battlefield identification system, second generation Forward Looking Infrared (FLIR), driver's thermal viewer, Commander's Independent Thermal Viewer (CITV), improved target acquisition system, and the Force XXI Battle Command Brigade and Below (FBCB2) system. The CITV allows leaders to acquire targets simultaneously in both primary and alternate sectors of fire, to rapidly access the situation of the entire unit independent of the gunner, and to observe the flanks and rear. Target engagement is improved by a ground-to-air capability and far target designation out to 5000 meters. Navigation is greatly improved for limited visibility conditions. The Inter-Vehicular Information System (IVIS) greatly improves command and control by allowing near real time transmission and receipt of combat data.

Bradley Linebacker - The Linebacker is a short-range air defense system for the heavy task force. The Linebacker was previously known as the Bradley Stinger Vehicle-Enhanced. It will replace the currently fielded Bradley Stinger Vehicle (BSV). The BSV has a crew of 5 people including a two-person Stinger team (manportable). It has internal storage racks to transport the missiles. The current BSV provides transportation under armor, but the team must dismount to engage enemy aircraft. The new Linebacker is essentially a Bradley with the tube-launched, optically-tracked, wire-guided (TOW) launcher replaced with an armored four-pack Stinger launcher and the Avenger computer system. It allows the crew to engage enemy aircraft while under armor. It will fire any Stinger missile. It will have non-cooperative target recognition,

second generation Forward Looking Infrared (FLIR), Global Positioning System (GPS), and a mounted compass for passive detection, tracking, and range identification by aircraft type. It will engage aircraft in clutter at extended ranges. The Linebacker fixes the survivability problem of the BSV and greatly enhances fire control, target acquisition, identification, and night vision. The Linebacker provides the team with access to the Forward Area Air Defense Command, Control, Communications and Intelligence (FAADC3I) system targeting display for rapid target orientation and acquisition. In addition, targets initially acquired by the Linebacker's magnified - sight optics, forward - looking infrared receiver, and visual target designation can be rapidly passed to the Stinger team. The Linebacker also provides a night vision capability. It operates with a four-man crew.

Chemical Imaging Sensor - This sensor will be capable of detecting known chemical agents and can be programmed to detect other militarily significant spectral data. It will expand the capability of current passive interferometry and signal processing to allow long-range chemical detection. The extended detection range capability can be employed by UAVs, helicopters, and high altitude reconnaissance systems.

Combat Identification for the Dismounted Soldier - This system is the individual soldier's link to the digital battlefield. It will improve situational awareness and target identification at the point of engagement by transmitting position and navigation information through a radio/computer system. The system provides an active, cooperative, interrogation, and friendly reply capability. It will interface with other battlefield platform identification devices in an integrated ground-to-ground and ground-to-air network. It should increase survivability by reducing fratricide and increasing combat effectiveness.

Combat Service Support Control System (CSSCS) - The CSSCS is the combat service support (CSS) component of the Army Tactical Command and Control System (ATCCS). ATCCS includes five distinct systems to support key Command and Control (C2) functions of maneuver, fire support, air defense, intelligence, and combat service support. While each C2 system provides detailed support of its battlefield functional process, it also shares pertinent information so as to provide all commanders with a common picture of the battlefield. This common picture helps ensure a more responsive and integrated execution of the commander's intent. CSSCS provides a concise picture of unit requirements and support capabilities by collecting, processing, and displaying information on key items of supplies, services, and personnel that the commanders deem crucial to the success of an operation. The management of all items within a class of supply or support function is accomplished with the Standard Army Management Information Systems (STAMIS). Items tracked in CSSCS represent a small and critical portion of the items managed by STAMIS. CSSCS supports the decision making process with course of action (COA) analysis. Staffs can analyze up to three COAs for a five day period. Variables include combat intensity, combat posture, unit task organization, miles traveled, and geographical region. CSSCS contains unit equipment planning factors and a database of equipment, parts, supply items, and personnel called the Baseline Resource Item List (BRIL). The items that a commander identifies as critical to the operation can be selected from the BRIL to establish the Commander's Tracked Item List (CTIL). CSSCS currently provides situation awareness of critical elements within supply classes I, II, III, IIIP, V, VII, IX, and personnel

strength management. Maintenance, transportation, and medical functionality are features that will be added as the system matures. CSSCS collects CSS data from multiple sources:

- Unit supply status and requirements are entered manually. Normally, inputs are entered at the brigade S4, main support battalion, or corps support battalion terminals, but they can be entered at any node. Electronic interfaces to future brigade and below C2 systems such as FBCB2 will greatly enhance the entry of unit consumption and requirements data. CSSCS tracks unit information down to the company level.
- Battle loss spot reports can be entered manually at any CSSCS node.
- CSS unit support capacities and capabilities can be entered via electronic or magnetic media exchange from the appropriate STAMIS.
- CSS reports can be obtained from other ATCCS systems.

The processed data is distributed to other CSSCS nodes via Mobile Subscriber Equipment (MSE). CSSCS nodes manipulate the data through a series of algorithms that are based on the specified task organization and established support relationships. This provides large quantities of data presented in comprehensive and useable decision support information formats. This information is graphically portrayed through green, amber, red, and black status depictions of force echelon, subordinate unit, and supply point status. Status may be projected out to five days using manually generated estimates. Simplified status reports can be further evaluated by the commander and his staff by accessing more detailed numerical data that supports the status displayed. CSSCS devices will be distributed down to brigade level for combat and combat support units, and down to battalion level for combat service support units. A total of 17 CSSCS nodes will exist in a division; 53 nodes will be in a typical corps structure not including those assigned to divisions. At brigade level there will be two CSSCS nodes, one in the brigade Administration/Logistics Operations Center (ALOC) and the other in the Forward Support Battalion (FSB) Support Operations Section. The brigade node is the point of entry in CSSCS for all unit level status and requirements for the support of the brigade. Through interfaces to the other ATCCS systems, this node provides the brigade ALOC with the battlefield common picture. The FSB node serves as the entry point for supply point data that is not supported by a STAMIS, and all the unit status for the FSB's subordinate units. The FSB can also view the status of the brigade it is supporting. Through interfaces with the other ATCCS systems, this node provides the FSB with the common picture of the battlefield. The FSB also uses this node to track and anticipate brigade logistics status, requirements, supply point status, and due-ins of CTIL items. The CSSCS will rapidly collect, analyze, and disseminate critical logistics information to support operations. It will provide timely logistics situation awareness to commanders and CSS operators at all levels in theater.

Common Ground Station (CGS) - The CGS provides combat information and intelligence data to the brigade commander. It consists of two High Mobility Multipurpose Wheeled Vehicles (HMMWVs) with shelters. It has the advanced antenna technology for receiving intelligence data while on-the-move from Satellite Communications (SATCOM) or airborne platforms. It is capable of receiving intelligence information from multiple sources, including UAVs, Joint Surveillance Target Attack Radar System (JSTARS) Moving Target Indicator (MTI)/Synthetic Aperture Radar (SAR), All Source Analysis System (ASAS), and Tactical Fire Direction System (TACFIRE). It will provide animated, interactive, multimedia intelligence

summaries (INTSUMs), and connectivity to sensor systems and tactical Command and Control (C2) via Secure Packet Radio, Single Channel Ground-Airborne Radio System (SINCGARS), Commander's Tactical Terminal Hybrid, and STU-III. It has an embedded simulation to demonstrate CGS functionality using man-in-the-loop.

Crusader - Crusader will be the indirect fire support "system of systems" providing fires in support of maneuver forces on the future battlefield. It is a 155 mm self-propelled howitzer that will provide a significant increase in artillery survivability, lethality, mobility, and operational capability and effectiveness. The Crusader will change how we employ artillery. Conventional howitzers are manpower intensive; the crew's focus is on the manual tasks of moving, positioning, preparing ammunition, loading, and setting firing data. With automation of these tasks resulting in greater capabilities in rate of fire and speed of movement, and with situation awareness, the howitzer can operate independently. Therefore, the section chief will become more involved in tactical decision-making and less with supervision of the firing tasks. The operating tempo (OPTEMPO) will be very high. Crusader will be designed to take full advantage of information dominance for the digital battlefield. Crusader features include:

- Longer range munitions - 40 km +.
- Increased rate of fire - 10-12 rounds per minute.
- Multiple rounds with simultaneous impact.
- Increased vehicle range and speed 450 km, 30 mph.
- New role for crew leaders - less gun oriented, more maneuver oriented.
- Leveraged information dominance (compatible with Advanced Field Artillery Tactical Data System [AFATDS], near real-time tracking, ammunition and fuel status automatically reported digitally).

Direct Broadcast Satellite/Joint Global Broadcast Service - This is a high speed, multimedia communications capability which provides information to installations, deploying units while in transit, and deployed units. It will provide worldwide, high capacity, one-way transmission of high-speed computer-to-computer data updates, high quality imagery, and near-real-time targeting data. It is planned to be an extension of the Defense Information System Network (DISN) and will send information asymmetrically to multiple addressees.

Dual Use Wireless Local Area Network (LAN) - This system will provide a wireless LAN capability (hubless) among Standard Integrated Command Post System vehicles and dismounted computers in a stationary command post.

Electro-Optical (EO) Marking Smoke - This smoke is detectable only by mid or far infrared sighting devices (can only be seen through a thermal viewer). It has application for traditional signaling functions and combat identification such as marking landing and drop zones, and targets. Most laser beams will not penetrate this smoke.

Enhanced AH-64 Apache - Apache improvements will include: capability for sensors to hand off prioritized targets to the fire-and -forget version of the Hellfire missile, control of UAV sensors, advanced tail rotor and transmission, and a composite gearbox housing. The enhanced Apache will have low acoustic, radar, and thermal signatures.

Enhanced Fiber Optic Guided Missile (EFOGM) - The EFOGM is a remotely directed, multi-purpose, precision kill weapon system capable of defeating armor out to 15 km. It is capable of defeating high value ground targets and hovering or moving rotary wing aircraft that may be masked from line-of-sight direct fire weapon systems. It features: imaging Infrared (IR)/visual sensor in the nose of the missile that will transmit the battle field picture to the gunner in day, night, or adverse weather conditions, and remote firing for gunner protection.

Enhanced Track Wolf - The Track Wolf is a wheeled vehicle that provides high frequency (HF) intercepts and direction finders. This system will use Signal Intelligence (SIGINT)/ direction finding (DF) development technology to provide non-cooperative intercept and geolocation of modern HF communications post activities. It targets rear echelon command post activities.

Force XXI Battle Command, Brigade and Below (FBCB2) - FBCB2 is a digital, battle command information system that provides commanders, leaders, and soldiers with integrated, on-the-move, real-time/near real time, battle command information and situational awareness from brigade down to the soldier platform level across all Battlefield Functional Areas (BFA). System capabilities are achieved by horizontal and vertical integration/aggregation of existing weapon systems, individual BFA, and tactical Command, Control, Communications, Computers, and Intelligence (C4I) system capabilities. FBCB2 interfaces with and is compatible with existing and planned Army Battle Command System (ABCS) initiatives and weapon systems. It integrates emerging and existing communication, weapon, and sensor systems to facilitate automated status, positional, situational, and situation reporting. FBCB2 provides the capability to receive and input status information provided by weapons systems, sensors, and support platforms to visually display situational awareness data, to receive, develop and distribute a common battlefield picture, and to prepare and distribute orders and graphics. FBCB2 will be implemented in four ways:

- FBCB2 hardware and Battle Command Software as a stand-alone capability with minimal integration with the platform.
- FBCB2 hardware and Battle Command Software integrated with a platform. Greater integration with other on-board systems.
- Embedded Battle Command Software in the platform's system software.
- Battle Command Software integrated / embedded into ABCS workstations.

Hardware will consist of a mix of stand-alone commercial-off-the-shelf (COTS), ruggedized or militarized FBCB2 components installed in tracked, wheeled, and airborne combat, combat support (CS), and combat service support (CSS) platforms. Embedded FBCB2 software will be installed in the M1A2 System Enhancement Program (SEP) Abrams tank and the M2A3 Bradley Fighting Vehicle. Embedded FBCB2 software may also be installed in the Army Aviation Command and Control System (A2C2S), Apache Longbow, Commanche, Crusader, Kiowa Warrior, Paladin, nuclear, biological, chemical (NBC) Reconnaissance System (NBCRS), Land Warrior (LW), and Multi-Functional Computer Systems (MFCS). The FBCB2 will use the Army Technical Architecture (ATA) and be compliant with Tactical Internet (TI) for distribution of information. A majority of data distribution will be via wireless links that are capable of operating on-the-move. The Tactical Internet consists of a system Position of Army

data and voice radios networked together using routers and commercial protocols. Radio systems used include current versions of the Enhanced Position Location Reporting System (EPLRS), Single Channel Ground and Airborne Radio System (SINCGARS) and when available, Near Term Digital Radio (NTDR). The system shall provide a common situational awareness picture that includes the following:

- Standard military map background.
- Elevation data.
- Feature and attribute data.
- Updated terrain data.
- Operations plans, orders, and overlays.
- Enemy obstacles.
- Own location/direction.
- Enemy locations (vehicle/unit/soldier).
- Friendly locations (vehicle/unit/soldier). (Friendly positions displayed horizontally within and across unit boundaries for two echelons below and two echelons above.)
- Neutral/noncombatant locations.
- Unit readiness status.
- Icons displayed in accordance with data received.

Future Combat System - This will be the replacement for the M1 Abrams Main Battle Tank. It will feature increased survivability including integrated vehicle defensive sensor and countermeasures, signature management, advanced armor, lightweight structure (40-55 tons), and active protection. Advanced fire control will include a 65 percent increase in multispectral target acquisition and a 100 percent increase in rate of engagement. Other improvements include advanced vehicle propulsion (electric drive), an active suspension, track with active tensioner; advanced electromagnetic cannon, and crew automation which includes loading and tracking.

Future Digital Radio - The Future Digital Radio is a networked, multiband, multimode high data capacity radio for the digital battlefield of the future. Its network will support the Tactical Internet Architecture, be Transmission Control Protocol (TCP)/ Internet Protocol (IP) Internet Compliant, and will include protocol functionality. The system will provide throughput of at least 144 kbps, including 300/2400 bps networked for all users all the time. It will support two separate and distinct waveforms. It will be able to operate with legacy systems.

Future Infantry Fighting Vehicle and Future Scout and Cavalry Vehicle - The concept envisioned is to design a light weight, composite structured, 12-22 ton fighting vehicle, tracked or wheeled, with an advanced multisensor target acquisition/designation suite, an integrated vehicle defense sensor/countermeasure with command and control (C2) on-the-move, an integrated signature management system, advanced mobility systems and adaptive suspension, advanced medium caliber weapon system, and an integrated crew station/mission specific hardware.

Ground Based Common Sensors-Heavy / Light - A new receiver architecture that will enable the ELINT/ES system to cover very wide instantaneous bandwidths (2 to 18 ghz). Technology will be developed to provide non-cooperative intercept and geolocation of new/modern signals.

It will provide communications intelligence (COMINT) intercept for high frequency (HF)/very high frequency (VHF)/ultra high frequency (UHF) single channel and low probability of intercept (LPI), and target nomination to QUICKFIRE CHANNELS. This system will be interoperable with Advanced QUICKFIX, Ground Based Common Sensor (GBCS)-Light, and Common Ground Station (CGS).

GUARDRAIL Common Sensor - GUARDRAIL is an upgrade to an existing system of fixed wing aircraft mounted COMINT, signal intelligence (SIGINT), and electronic intelligence (ELINT) systems. It provides COMINT, SIGINT, and ELINT capability to support reconnaissance, surveillance, and suppression of enemy air defense (SEAD) missions. It will provide direction finding to support targeting of threat emitters. It will be assigned to corps level and selected theater level Military Intelligence (MI) brigades.

Guided Multiple Launch Rocket System (GMLRS) - This program increases the range of the Multiple Launch Rocket System (MLRS) from 32 to 45 km and improves guidance system and munitions. This program makes the MLRS more lethal and requires no change to crew training procedures or maintenance procedures.

Guided Parafoil Air Delivery System - This is the next generation air delivery system with three variants of load capacity: Light (750-1000 lb), Medium (15,000 lb), and Heavy (28,000-42,000 lb). It will be capable of autonomously delivering (drop and forget) payloads accurately within 100 meters of target location from altitudes of up to 25,000 feet. The increased delivery accuracy is made possible by a GPS-based guidance and control system and actuated risers. This system, provides increased safety for delivery aircraft.

Handheld Standoff Mine Detection System- This is the replacement for the current portable mine detector. It is a man portable system capable of detecting surface and buried metallic and non-metallic anti-personnel (AP) and anti-tank (AT) mines. Technologies under consideration are separated aperture detector, synthetic pulse radar, balanced bridge detector, and thermal imagery.

Hellfire Long Bow - This improved Hellfire missile is designed for employment with the Longbow radar fire-and-forget advanced missile system. The Longbow sensors will hand off prioritized targets to the Hellfire missile "seekers."

High Capacity Artillery Projectile - This is a 155 mm artillery projectile with a two-piece modular cargo. The projectile is loaded separately and bonded in the weapon's chamber. It has a greater payload (>39" overall length) at current range, or an equal payload at extended range. Other features include: low radar signature, reduced tube wear, lightweight structure, and fin stabilization.

High Capacity Trunk Radio (HCTR) - This wideband, line-of-sight (LOS) radio will be the replacement or upgrade to the AN/GRC-226. It is a high capacity trunk radio for the Mobile Subscriber Equipment (MSE). It will have two modes of operation: stationary and on-the-move (OTM). In the stationary mode HCTR provides wideband multichannel trunking for MSE. It will be compatible with Asynchronous Transfer Mode (ATM) switching envisioned to be used

by the Army in wide area backbone nodes, local area hubs, and mobile systems. It may be operated as an integral part of the Radio Access Point (RAP), which will incorporate an ATM switch providing a gateway to various narrow band tactical communications systems. It will be an integral part of the RAP to provide an OTM high capacity (up to 155 mbps) data throughput for the Digital Battlefield Communications (DBC). It will have extended range capability via an airborne relay and the OTM antenna.

Integrated Biodetection - The Integrated Biodetection Advance Technology Demonstration (ATD) will demonstrate the integrated point and standoff detection of biological agents using state-of-the-art technology. The purpose is standoff detection and mapping using active laser detection at distances from 5 to 40 km. It will focus on point biosensors that have enhanced reliability, stability, sensitivity, and response times. It will integrate state-of-the-art biological-detection technologies into the Biological Integrated Detection System (BIDS) and the Joint Biological- Point Detection System (JBPDS).

Javelin - Javelin is a man portable antitank weapon which will replace the M47 Dragon. It is shoulder fired and can be installed on tracked, wheeled, or amphibious vehicles. The Javelin consists of the Command Launch Unit (CLU) and the Launch Tube Assembly (LTA). The CLU has thermal capability for use at night or in reduced visibility. The round has a fire-and-forget capability, which locks on before launch and activates automatic self-guidance after launch. The missile range is 2000 meters. The missile is propelled by solid rocket propellant and is fired with a low smoke signature and a soft launch, which provides a capability for use in enclosed spaces (buildings or bunkers). The soft launch ejects the missile forward a distance before the second stage propellant starts. The gunner can select two modes of attack, direct or top down. In the top down attack mode the Javelin climbs above the target and strikes down from the top to penetrate the weak armor on top of vehicles.

Joint Transport Rotorcraft - This is a tri-service project to replace the CH-47 and CH-53 helicopters. The helicopter will feature: low acoustic, radar, and thermal signatures, a 30% increased payload and range over current helicopters.

Land Warrior Block I - This is a lightweight, shoulder-fired, multipurpose weapon to defeat a variety of targets, such as enemy forces in buildings, bunkers, and light armored vehicles.

Low Profile Ultra High Frequency (UHF) Satellite Communications (SATCOM) On The Move - This ultra high frequency, low profile antenna (objective: 12" in height and 24" in diameter) designed to be mounted on various vehicles. It has a high gain, low noise amplifier with omnidirectional radiation pattern in the upper hemisphere for operation while on-the-move (up to 50 mph). It will operate with the AN/PSC-5 Enhanced Manpack Ultra High Frequency (UHF) Terminal (EMUT), which uses the Demand Assignment Multiple Access (DAMA) standard protocol. It will send full-duplex voice and high data rate (16 kbps information) communications to geosynchronous satellites.

M56 Large Area Smoke System P3I - The purpose of this system will be to defeat smart weapons. It is an upgrade to the current M56 Large Area Smoke Generator, which only screens the visual and Infrared (IR) bands. The millimeter wave (MMW) module will prevent threat

MMW radar from acquiring and tracking friendly targets. Aerosol technology and chemical dispersion techniques will be used. The objective system will generate smoke while moving at 30 mph.

Medium Altitude Endurance Unmanned Aerial Vehicle (UAV) Payload - The platform for this payload package is the Predator UAV. In combination, the UAV and its payload provide long-dwell time, day/night, most weather, long-range (to 500 nm), wide-area, real-time reconnaissance and surveillance capability. It will down-link high resolution (0.3 m) continuous strip map imagery (800 m swath width at speed of 35 m/sec) from altitudes ranging from 2 to 7.6 km (5 to 23 kft). The imagery is compressed and transmitted at 1.5 mbps from 30" dish antenna in the UAV to a commercial KU Band Satellite relay, then to a Synthetic Aperture Radar (SAR) Ground Control Station (GCS). The SAR 36-element phased array antenna scans mechanically in azimuth, and electronically in elevation. The UAV and SAR are controlled from GCS via KU Band Satellite relay with exploitation of imagery conducted at GCS in real-time. SAR Target Recognition and Location System (STARLOS) will be developed for the GCS and will identify targets against clutter backgrounds.

Medium Extended Air Defense System - This is a highly mobile, stand alone, high fire power, medium range air defense system which will replace the Hawk and Chaparral. It will be able to counter tactical ballistic missiles and air breathing threats to include cruise missiles and UAVs. It will operable in a heavy Electronic Counter Measures (ECM) and anti-radiation missile environment. It will be deployable by C-130 aircraft (roll on, roll off) and will use 1/2 the aircraft space required by the Patriot.

Mine Hunter Killer - This is a tele-operated vehicle that will detect and kill mines and unexploded ordnance at a standoff distance while the vehicle is moving. This vehicle will be outfitted with low cost/low observable technology to improve survivability and will fully integrate a countermine system that employs infrared detection, millimeter wave (MMW), and directed energy/explosives technologies to provide a 10 fold increase in neutralization range (5 meters to 50 meters) and a two fold increase in breaching speed, from 5 mph to 10 mph.

Miniature Hypervelocity Kinetic Energy (KE) Missile - A hypersonic/hypervelocity (Mach 6-8) missile with a Depleted Uranium (DU)-rod, and millimeter wave guidance.

Multispectrum Smoke and Obscurant - This smoke will obscure or defeat threat reconnaissance, intelligence, surveillance, and target acquisition (RISTA) assets in broad bands of electro-magnetic (EM) spectrum (visual to MMW and IR). It provides a remote, rapid neutralization of threat Directed Energy Weapons (DEW) on a point or limited area basis for five minutes. It will defeat smart weapon sensors by using smoke to break target acquisition lock of smart weapon IR sensors or divert munitions from intended target. It places emphasis on material packaging and dissemination techniques to increase bulk density, particle aerosolization, and pyrotechnic dissemination. Follow-on to this effort will be an autonomous smart weapon defeat capability that will detect the threat automatically and activate the countermeasure for survivability. (Environmental concerns [pollution measurements/impacts] could impact systems utilization, particularly in the training environment. Toxicity to the soldier is also a concern.)

Objective Crew Served Weapon (OCSW) - The OCSW will be the replacement for the current heavy and grenade machine guns. It will be a two person crew portable weapon, weighing less than 38 lbs. to include tripod and fire control panel. The 25 mm high explosive rounds will be in two forms: air bursting and armor penetration. It will have a laser rangefinder, night vision (millimeter wave or long wave infrared), and a ballistic computer.

Objective Individual Combat Weapon (OICW) - The OICW is designed to be the individual weapon of the future. It will replace the M16, M203, and M4 carbine weapons with a single weapon system that will have the capabilities of all three. This weapon will improve target detection and acquisition with a highly sophisticated fire control system that has automatic ranging capabilities. The OICW will provide the capability for an individual soldier to effectively detect, acquire, and engage personnel exposed, in defilade, or in lightly fortified positions, all vehicles without armor and some with light armor, and low flying, slow moving aircraft. It provides target acquisition under conditions of limited visibility (night, smoke, fog, dust, and haze); it minimizes shooter errors common with current weapons. The OIWC will use advanced munitions in the form of a 5.56 mm kinetic energy round and a 20 mm air-bursting round. It will have a laser range finder that determines exact range to the target and transmits that information to its fire control system, which will determine the exact range at which the 20 mm high explosive (HE) round should detonate. It will have a laser dot marking system for use in urban areas and for targets in defilade. The weapon will have reduced recoil. It will be lighter than current weapons and have an effective range of 1000 meters. It may use caseless munitions technology.

Objective Personal Weapon (OPW) - The OPW is the replacement for the M9 9 mm and Caliber .45 M1911A1 semi-automatic pistols. It will have a probability of hit of 0.9 at 50 meters and 0.5 at 100 meters. It will defeat personal body armor at 50 meters. It will be lightweight (less than 3 pounds fully loaded). It will be easily stowed. It may use a laser sighting-aiming device.

Off Route Smart Mine Clearance (ORSMC) - The ORSMC is a countermeasure technique to neutralize off-route smart mines, with focus on side-attack mine systems. The ORSMC will use remotely controlled vehicles to neutralize acoustic, seismic, and infrared sensors that detect, classify, track targets, and then, launch munitions. ORSMC will emulate the acoustic, seismic, and infrared signatures of combat vehicles and "spoof" the mines into a premature launch. It supports conventional minefield breaching and clearing operations. It projects multi-spectral target signatures to initiate smart mines.

ORION - This is a wideband Signal Intelligence (SIGINT) Electronic Support (ES) package for UAV applications to obtain deep target data for processing by the Intelligence and the Electronic Warfare Common Sensor. It is a capability to locate high value C2 targets, including low signal levels from directional systems such as multichannel. It mitigates interference problems from friendly, close-in, relatively high powered signals.

Patriot Advance Capability (PAC) - III - This is a hypervelocity missile with hit-to-kill accuracy against tactical ballistic or maneuvering missiles. It is launched from a Patriot launcher

with four missiles per Patriot tube. It has an on-board high performance KA band seeker and a state-of-the-art launch control system, which can be integrated into existing fire control radar.

Phased Array Communications Antenna (PACA) - The PACA consists of a five panel phased array antenna integrated in a van/shelter to provide on-the-move capability via airborne relays, terrestrial line-of-sight (LOS) stations, and satellites. It provides simultaneous reception of multiple beams in either X or KU Bands, and transmits in either X or KU Band. The PACA is adapted from the Advanced Antenna Prototype Subsystem. It provides the wideband capability required by the Radio Access Point and High Capacity Trunk Radio.

Precision Guided Mortar Munition - This is a "smart," precision guided, 120 mm mortar round, with an autonomous IR seeker and point target (Semi-Active Laser) capability. It is a gliding flight, terminally guided, top attack munition with improved range (12 km required, 15 km desired). It has a tandem shaped charge, which can be set by a mortar squad according to mission. It has a six rounds per minute sustained rate of fire capability.

Precision Off Set, High Glide Aerial Delivery of Munitions and Equipment - A precision guided delivery system for combat vehicles, munitions/sensors, and other equipment. It employs a deployable gliding decelerator, and incorporates a low cost, modular GPS guidance system. It will be a three-fold increase in offset capability over the current system. It can air deliver up to 10,000 pounds using high glide wing technology.

Radio Access Point (RAP) - The RAP will distribute data from continental United States or sanctuaries in the rear of a theater to forward areas. It supports on-the-move (OTM) communications with fixed or stationary terminals, and aerial vehicles (e.g., UAVs). It incorporates Asynchronous Transfer Mode (ATM), Phased Array Antennas, Wideband Data Radios (e.g., Near Term Digital Radio [NTRD]), and High Capacity Trunk Radios (HCTR). It provides wideband switching for ATM at data rates of 155 mbps with HCTR (45 mbps in degraded mode) and interfaces with Combat Net Radio (e.g., Single Channel Ground-Airborne Radio System [SINCGARS]), Mobile Subscriber Radio Terminal (MSRT), Future Digital Radio (FDR)/NTDR, and UAVs.

RAH-66 Comanche - The Comanche replaces the Kiowa Warrior (OH-58D) as the reconnaissance helicopter supporting the Apache attack aircraft. It has low acoustic, radar, and thermal signatures. The aircraft and its sensors will be resistant to directed energy weapons. It fires advanced fire-and-forget missiles and integrates new information technologies to include cognitive decision aids for the pilot.

Raptor - Raptor was formerly known as the Intelligent Minefield (IMF). Raptor is the integration of smart munitions, advanced sensors, and command and control technologies to provide the future warrior with a capability to dominate a particular area of the battlefield either through direct control or autonomously. Raptor will be able to track, identify, and defeat a variety of ground and airborne threats either through direct or indirect fires. The initial purpose of the Raptor was control of mine fields, but it has evolved into an unmanned terrain control/protection system that, on cue, can report enemy locations or engage the enemy with direct and indirect fires. It consists of a control station, sensors, and smart munitions. The

system will be integrated with the Army Battle Command System (ABCS) and will embed decision aids, as well as a mission planning and rehearsal capability. The control station will be able to communicate two ways with its sensors at a distance up to 300 kilometers. The Raptor will add an acoustic overwatch sensor, a long haul communications capability, and a local computer control node (internal to the minefield) to coordinate the actions of emplaced wide area munitions (WAM). The Raptor can report individual vehicles, aircraft, personnel, and the composition and movement direction of enemy formations. With control of the sensors and munitions from a remote location, the mines can be command-detonated. The Raptor, when deployed deep, can cue artillery strikes, adjust them, report remaining targets, and provide weapons effects assessments for possible follow-on strikes. The M93 Hornet WAM is being used as a springboard to help create this new system. The Hornet is programmed for a Product Improvement Package (PIP) in the near term. The PIP adds a two-way communication capability to the mine using a Single Channel Ground-Airborne Radio System (SINCGARS) radio system to link with a hardware computer control unit with a line of sight range of 3-5 kilometers. With this new capability the WAM can be turned on and off and queried to confirm its status. If its legs are not extended, the Raptor can be used as a remote sensor which can be later picked up and moved. If the legs are extended, the WAM reports every target it detects to the computer control unit. Prior to engaging, Raptor reports the target type it is about to attack. An additional PIP will include a repeater to extend the WAM's communication range.

Remote Sentry - The Remote Sentry will consist of an unattended remote sensor suite, which will be placed behind enemy lines or in forward areas. It has a laser range finder, camera, and daylight TV, second generation forward looking infrared radar (FLIR) (8-12 micron), and acoustic sensors. It can send secure data transmissions using Single Channel Ground-Airborne Radio System (SINCGARS) or a radio packet yet to be developed. It has an all-weather, limited visibility intruder detection and assessment capability. The detection ranges are 2200 m for ground vehicles and 1100 m for personnel with a field of view of 360 degrees. It is air deliverable and man-portable (75 pounds, with 4 cubic feet of volume).

Satellite Personal Communications System (PCS) - The universal PCS handsets and military gateway receiver will exploit emerging low earth orbit (LEO) commercial satellite systems for autonomous battlefield communications worldwide. The applications include voice, facsimile, data, and paging communications. Universal PCS handsets are to be ruggedized and capable of communicating via multiple service providers. The candidate LEO satellite systems include: Iridium (Motorola), Globalstar (Loral/Qualcom), Odyssey (TRW), Orbcomm, and Ellipsat (Ellipso). The PCSs utilize L-Band and S-Band frequencies and Code Division Multiple Access (CDMA) of Time Division Multiple Access (TDMA). The military gateway provides links between multiple providers and the Public Switched Telephone Network (PSTN).

Sense & Destroy Armor P3I - This is the follow-on to the Search and Destroy Armor (SADARM) submunition. It has an expanded submunition search area and a greater lethal range (over SADARM) via the parafoil concepts. It is Multiple Launch Rocket System (MLRS) and 155 mm munitions compatible. It features identification friend-or-foe (IFF) with target pattern recognition, an imaging infrared (IR) sensor (0.8 micron), countermeasure resistance, and dual warheads (self forging or fragmenting) with explosively formed penetrators. It is autonomous.

Super High Frequency (SHF) Airborne Relay - This system provides communications technology for installation of relay packages on airborne platforms to extend the range of communications. It provides range extension for SHF legacy terminals and for the High Capacity Trunk Radio (HCTR) utilizing Asynchronous Transfer Mode (ATM) at data rates of 45 mbps and/or 155 mbps. It provides a surrogate satellite platform for the Personal Communications System (PCS) to relay communications from terrestrial switched entry points and to the PCS subscribers. It also provides a surrogate platform for Direct Broadcast Satellite (DBS) communications, a range extension for Radio Access Point (RAP) to HCTRs, and other RAPs. The airborne platform infrastructure, including its Command and Control (C2) communications, is a separate system.

Tank Extended Range Munitions - This is a kinetic energy (KE) round for the 120 mm tank gun. It will result in direct fire beyond the tank's line of sight with a rocket-assisted KE penetrator. The muzzle velocity produced will be 800 m/s with subsequent acceleration above 1500 m/s. It is a fire-and-forget round with an increased hit probability over current KE penetration rounds.

Unmanned Aerial Vehicle (UAV) Hunter - The Hunter Joint Tactical UAV is the baseline system within the Joint Tactical UAV program. It is designed to provide both land and maritime forces with near-real-time imagery intelligence within a 200 km direct radius of action, extendible to 300+ km by using another UAV as an airborne link relay. Hunter will operate from improved or unimproved airstrips to support corps and division level Army and Marine Corps commanders. The system will be comprised of eight air vehicles, four Remote Video Terminals, three Ground Control/Mission Planning Stations, two Ground Data Terminals, one Launch & Recovery System, and one Mobile Maintenance Facility. The primary payload is a television camera for daylight observation and a FLIR camera for night observation which will transmit high quality, day/night images. The UAV cameras can be linked through the Ground Based Common Sensor (GBCS) and through the All Source Analysis System (ASAS) to Force XXI Battle Command Brigade and Below (FBCB2). UAV operations consist of:

- Setup and pre-flight of the system.
- Planning and coordinating the flight.
- Launch and flight control.
- Monitoring imagery.
- Modifying flight plans during flight.
- Acquiring and processing battlefield intelligence and targeting data.
- Landing and retrieval.

Procurement of this specific system has been stopped, but it is the baseline for expected follow-on UAV development.

Unmanned Aerial Vehicle (UAV) Short Range Close Range Intelligence Package - This system supports targeting of high value C2 targets. It employs advanced electronic countermeasures against complex advanced modern communications signals. It has day and night sensing and countermeasures.

Vehicular Mounted Mine Detector - This system will be a mounted capability to detect metallic and non-metallic mines, conventionally or remotely emplaced. The system's rate of movement is expected to be 3 mph with a standoff distance of 30 to 75 feet. The system will consist of a detection array operator screen display, data interpretation algorithm, and a power source. Three technologies will be used: Ground Penetrating Radar (GPR); FLIR; and electromagnetic induction. This system is characterized by advanced image processing, real time data transfer, automatic target recognition algorithms, and a teleoperation capability.

Wireless Network Access - This is a new generation wideband radio that will provide networking among dispersed, mobile local area networks in a tactical environment (brigade and battalion level). It will support high capacity data and voice users in command vehicles. It operates in the Ultra High Frequency (UHF) band (12 MHz bandwidth) with an omnidirectional antenna. It will provide a maximum data rate of 5 mbps over a maximum range of 10 km, which includes multiple hops. It features self-configuring and automatic reconfiguration of transmission routes with anti-jamming which results in a low probability of being intercepted. It operates in autonomous configuration or connects to the Mobile Subscriber Equipment (MSE) Packet Network (MPN).

XM829A3 APFSDS - This will be an improved 120 mm tank gun direct fire round utilizing an advanced Kinetic Energy (KE) cartridge. The round will use an axial thruster and advanced propellant to enhance accuracy. This system is expected to defeat enhanced reactive armor. It will increase penetration by 40 - 50 % and probability of hit by 30% over the M829A2 round at extended ranges (3 km).

XM943 Smart Target Activated Fire And Forget Projectile - This is a "smart" anti-armor round for the 120 mm tank gun that provides a direct fire top attack fire-and -forget capability. It has an explosive forming penetrator warhead that is fused above the target for armored targets. It can be used against rotary wing aircraft.

Appendix D

Information Sheets for Selected Simulations

The simulations selected for the study on Simulation Training Strategies for Force XXI were Joint Simulation System (JSIMS), Warfighter Simulation (WARSIM) 2000, One Semi-Automated Forces (ONESAF), Aircraft Reconfigurable Simulator (ARMS), Combined Arms Tactical Trainer (CATT), and Home Station Training Instrumentation (HTI). Detailed descriptive data sheets were developed for use as background material for the study.

Joint Simulations System (JSIMS)

Description: JSIMS will provide joint training for commanders-in-chief, their component commanders, and other joint organizations. JSIMS will overcome many of the shortcomings in today's simulations, which include inadequate representation of logistics, intelligence, space, special operations, and the social, economic, and political factors of Operations Other Than War (OOTW). JSIMS will have a rapid scenario generation capability for exercise planning. It will provide the common objects, a real time hardware and software infrastructure, and interfaces. The air and space environment will be represented by the National Air and Space Model (NASM), the land environment by WARSIM, and the sea environment by the Maritime Simulation (MARSIM). JSIMS will use the National Simulation System and WARSIM Intelligence Module (WIM) for intelligence simulation. JSIMS will link live and virtual training simulations using the players' C4I systems over a secure, high-speed, distributed network.

- WARSIM (land component of JSIMS) - The Army will use WARSIM to train commanders and staffs from battalion to theater level in both joint and combined scenarios. WARSIM will use mostly existing C4I equipment in lieu of player stations, allowing worldwide training at command posts. Semi-automated forces (SAF) will reduce the number of exercise controllers needed to run the exercises. WARSIM will provide the common synthetic environment for JSIMS.

- NASM (air and space component of JSIMS) - NASM will be the Air Force's constructive simulation for training their commanders and staffs. NASM will use unit C4I systems to interface with the simulation, computer generated forces (CGF), and human-in-the loop virtual simulators flying through instrumented ranges and operating live command and control (C2) systems. The simulation will realistically represent the full range of aerospace capabilities in a joint synthetic battle space including air defense, C2, Airborne Warning and Control System (AWACS), Joint Surveillance Target Attack Radar System (JSTARS), combat air patrol, close air support, radar and surface-to-air missiles sites, and enemy aircraft. NASM will be scaleable to support mission level training from wing through air component commanders. NASM will run from real time up to 100 times greater than real time.

- MARSIM (sea component of JSIMS) - The simulation supports training of the conduct of naval warfare tasks – strike warfare (STW), surface warfare (SUW), air warfare (AW), undersea warfare (USW), amphibious warfare (AMW), command and control warfare (C2W), and mine warfare (MIW). MARSIM supports training of Navy commanders and their staffs in the maritime arena. MARSIM will simulate multiple battle groups and their supporting forces across the full spectrum of naval warfare. It will simulate units and individual ships, submarines, and aircraft in maritime areas and represent the functional activities of those units both at sea and in the littoral. For replicating amphibious operations, MARSIM will support execution of landing plans, in which amphibious assault troops will disembark landing craft and/or helicopters, assemble, and proceed to their objective areas automatically. Amphibious assault vehicles also will come ashore, assemble, and automatically proceed to their objective areas.

JSIMS will be a comprehensive tool to satisfy many uses. JSIMS includes a core infrastructure and mission space objects maintained in a common repository. The objects can be composed to create a simulation capability to support joint or service training, mission rehearsal, or education objectives.

Key Features:

- Constructive simulation.

- Training audience: Joint force commanders and staffs, principle subordinate service and functional component commanders and staffs, will be trained in operational and strategic joint tasks. Eventually, JSIMS will evolve into a robust, interactive joint synthetic battle space for training strategic and national joint tasks and each of the Service's tactical tasks in all phases of operations. It will also have the capability to satisfy a full range of training, education, doctrine development, and mission rehearsal needs.

- Incorporation of simulations across the full range of military operations including: land, sea, air, space, and special operations; associated functions such as logistics, transportation, intelligence, medical, engineering, communications, and electronic warfare; and geospatial, meteorological, oceanographic, and environmental factors.

- Incorporation of simulation of social, economic, and political factors which affect, or are affected by, missions across the entire range of military operations.

- Tailored displays of simulation results on C4I systems or their emulation for training and exercises, or on computer workstations for analysis.

- Distributed and remote computer processing for users located at dispersed sites.

- Flexibility to accommodate different functional applications and levels of detail within those applications (e.g., tactical, operational, and strategic levels of warfare for training and exercise).

- Linkage of live, constructive, and virtual forces to form an environment that stimulates a user's C4I systems.

- Accelerated development of data/knowledge bases and the creation of SAF to reduce exercise overhead and allow for crisis rehearsals.

Warfighter Simulation (WARSIM) 2000

Description: WARSIM is a computer based simulation to support training of headquarters and command posts from battalion through theater level in joint and coalition scenarios. WARSIM will provide a synthetic environment for commanders and their staffs to exercise in multiple scenarios with realistic threat, terrain, and weather conditions. The simulation is designed so that designated units may interface directly with WARSIM through their organic C4I systems, allowing commanders and staffs to operate as they would in combat. WARSIM is designed to be capable of linking to virtual simulator (e.g., CATT) exercises, and instrumented live exercises. It replaces Brigade and Below Battle Simulation (BBS), Corps Battle Simulation (CBS), Combat Service Support Training Simulation System (CSSTSS), and Tactical Simulation (TACSIM). TACSM, the current intelligence simulation, will be replaced by the WARSIM Intelligence Module (WIM).

WARSIM can be used for training, mission rehearsal, and mission planning. Additionally, WARSIM can be used to assess new concepts for doctrine, training, leader development, organizations, and materiel. With WARSIM, commanders can conduct exercises independently or under the supervision of observer controllers. WARSIM will support the complexity of a Battle Command Training Program (BCTP) exercise as well as the simplicity of a single battalion commander's staff training exercise. At full operational capability, the training environment will be significantly enhanced by WARSIM's capability to surround a player unit with computer generated forces and cognitive models to represent interaction with friendly units to the flanks, rear, or front, as well as enemy forces.

Key Features:

- Constructive simulation.

- Simulation interfaces with unit's organic C4I.

- Supports single and multi-echelon training exercises and large scale distributed exercises (division, corps, theater, joint and combined).

- Training audience: Commanders and staffs at battalion through theater levels.

- Supports the full spectrum of force projection (mobilization, deployment, early entry operations, operations, sustainment, reconstitution, redeployment, and demobilization).

- Supports full dimension operations ranging from war to OOTW.

- Portrays the effects of space, air, naval, and amphibious operations.
- Provides the land component portion of JSIMS.
- Provides DIS standard interoperation with virtual simulator training systems, live instrumented range systems, WARSIM, other Army constructive simulations, and other joint service simulation systems.
- Reduces the overhead associated with support of current command post simulation training systems, while meeting the training requirements across the spectrum of Army operations from war to OOTW.
- Will be installed in three new Regional Training Centers (RTCs), each capable of conducting up to ten independent simultaneous seminars, battalion and/or brigade exercises, and up to a corps exercise in a stand alone mode. With interoperation of centers, the system will support multi-corps, theater, or large joint and combined operations. WARSIM will also be resident in the existing installation simulation centers.
- Simulation support modules will provide the capability to support training audiences not located at a RTC, e.g., deployed units, National Guard and Army Reserve units at their training facilities, the other services, and foreign armies.

One Semi-Automated Forces (ONESAF)

Description: ONESAF is a composible next generation of CGF that can represent a full range of operations, systems, and control processes from individual to battalion level with a variable level of fidelity to support all three modeling and simulation domains. Individual combatants and systems can communicate, acquire targets, deliver accurate fires to targets, kill targets, and move in a realistic environment with behaviors controlled by operators or by automation. Specific activities of combat, C4I, combat support, and combat service support elements will be represented for joint and coalition operations up to brigade level. ONESAF will provide the capability to exercise a brigade level scenario for friendly, or blue, forces (BLUEFOR) and will link to other simulations to create exercise events at higher levels. The Opposing Forces (OPFOR) will be replicated from individual up to division level. ONESAF will also model appropriate representations of the physical environment and their effects on simulated activities and behaviors.

Key features:

- Simulates maneuver and force-on-force engagements.
- Supports unit training by providing OPFOR and round out forces.
- Supports unit mission planning process.
- Provides linkages between live, virtual, and constructive environments.

- High Level Architecture (HLA) compliant.
- Interoperability with WARSIM, CCTT, and units C4I systems.
- Scaleable in fidelity and size.
- Represents the effects of dynamic terrain, weather, day, night, obscurants, countermeasures and nuclear, biological and chemical (NBC).
- Selectable exercise time (ranges from real time to faster than real time).
- Supports training in low, mid, and high intensity conflicts.

Aviation Reconfigurable Manned Simulator (ARMS)

Description: The Aviation Reconfigurable Manned Simulator (ARMS) is being procured for the U.S. Army National Guard (ARNG). It will serve as the primary trainer for collective tasks, while simultaneously supporting sustainment training of individual and crew tasks in ARNG aviation units. The concept is to field a low-cost, transportable/deployable simulator that will reduce training costs and provide a means to sustain collective skills. The ARMS training focus will be at company level. ARMS will provide training of missions for a variety of aircraft (AH-64A, AH-1, OH-58D, UH-1, UH-60, CH-47D). The strategy requires the fielding of 36 mobile ARMS devices to six regions across the United States. The regional concept provides for centralized maintenance, scheduling, and training support allowing units to minimize planning, and to maximize training time. The devices are reconfigurable to the six rotary wing airframe types flown in the ARNG. ARMS is interoperable with DIS and is an integral part of the Army Aviation Combined Arms Training Strategy (AVCATS). The ARMS system will train company level collective tasks. It provides a practical method for training the collective tasks in combat environments with an interactive threat array. ARMS will augment CPXs and FTXs. The ARMS system can also be used for mission rehearsal, SOP development, and gunnery exercises.

Key features:

- Virtual simulation which will be linkable to other virtual simulators and to constructive simulations through unit C2 systems.
- Interoperable with CCTT.
- HLA compliant.
- Reconfigurable.

- Easily transportable to other facilities and is deployable for use in contingency operations.

- Training audience is company and below. Training audience includes the Attack Helicopter Company (ATKHC), Target Acquisition and Reconnaissance Company (TARC), Acquisition Air Cavalry Troop (ACT), Assault Helicopter Company (AHC), Command Aviation Company (CAC), General Support (GS), Light Utility Helicopter (LUH) Company, and in some cases the Air Ambulance Company (AAC). The audience includes full aircrews for various scout, attack, and utility helicopters. Battalion command and staff support is required in a supporting role during ARMS training.

Combined Arms Tactical Trainer (CATT)

Description: The CATT is a collective combined arms trainer that will provide commanders, up to battalion task force level, the opportunity to train in a realistic, force-on-force, virtual battlefield environment. CATT uses a combination of manned simulators, workstations, SAF, and DIS technology, for both proficiency and sustainment training of selected individual, crew, collective, staff, and combined arms tasks. The five systems that will make-up the CATT program are:

- The Close Combat Tactical Trainer (CCTT).

- The Aviation Combined Arms Tactical Trainer (AVCATT).

- The Air Defense Combined Arms Tactical Trainer (ADCATT).

- The Fire Support Combined Arms Tactical Trainer (FSCATT -Phase II).

- The Engineer Combined Arms Tactical Trainer (ENCATT).

CATT consists of several components which can be grouped into two categories - manned simulators and the CATT nucleus (core) environment. The manned simulators are the vehicle (air and land) and weapon system simulators which are currently the focal points of each CATT system. As the proponents for these five systems complete their project requirements, the result will be the requisite fidelity to support the training of individual, crew, collective, and combined arms tasks. The second category of CATT is the core environment which consists of elements that are common to all proponent combined arms virtual training system requirements. The core environment forms the base upon which the CATT virtual training program will grow and includes:

- SAF.

- Terrain databases and rapid database generation tools.

- Data, models, and algorithms.
- Workstations.
- C4I interface systems.
- Standard Army After Action Review System (STAARS) and analytic tools.
- Local Area Network (LAN) and Wide Area Network (WAN) capability.
- Technology transfer from the DIS technology base.
- CATT buildings.
- CATT Contractor Logistics Support (CLS).
- Training Support Packages (TSPs).
- After Action Review (AAR) tools.

CATT Simulators:

- Air Defense Combined Arms Tactical Trainer (ADCATT) - ADCATT will be a distributed process, networked simulation system which allows Forward Area Air Defense (FAAD) units to train collective tasks associated with the support of mechanized and armor maneuver units. It consists of mobile platoon sets of the Avenger or Bradley Linebacker. Emulator workstations represent the Forward Area Air Defense Command and Control (FAADC2) network. Combat Support (CS) and Combat Service Support (CSS) functions of the combined arms battlefield are included in each platoon set. In addition, SAF workstations, which replicate realistic opposing forces and supplemental friendly forces, are also provided. An AAR station provides performance feedback for the crews ensuring that all training is performed to standards. ADCATT is capable of operations in a stand alone mode using SAF or it can be networked with other CATT systems.

- Aviation Combined Arms Tactical Trainer (AVCATT)- AVCATT will be a distributed interactive, networked simulation system which allows for individual, crew, collective and combined arms training. Adequate numbers of manned aviation simulators will be fielded to replicate attack company, reconnaissance troop, and assault platoon configurations. AVCATT will be comprised of the AH-64 Attack Helicopters; RAH-66, CH-47, OH-58D, and UH-60 systems, as well as the UH-1 and AH-1 for the Reserve Forces; emulator workstations representing staff functions and command, control, communications, and intelligence (C3I), CS, and CSS aspects of the combined arms battlefield; and SAF replicating enemy forces and/or augmenting friendly forces.

All battlefield operating systems will be represented in the simulation. AVCATT will provide for both stand-alone aviation specific training and interaction with other collective task trainers, i.e., CCTT and ADCATT, thereby providing the aviation link to a total combined arms tactical training device strategy.

- Engineer Combined Arms Tactical Trainer (ENCATT) - ENCATT will allow engineers units to train tasks associated with C2, mobility, countermobility, and survivability on a simulated battlefield in a dynamic environment.

- Close Combat Tactical Trainer (CCTT) - CCTT is a distributed processing, networked simulation system which allows mechanized infantry and armor units to conduct tactical maneuver training in a combined arms, computer simulated combat environment. It is composed of various simulators replicating the combat vehicles, tactical vehicles, and weapon systems of a heavy maneuver company team interacting in real-time with each other and SAF OPFOR. Units operating on the simulated battlefield are supported by CS and CSS operating systems organic to or in direct support of the battalion/task force. All battlefield operating systems are represented in the simulation.

- Fire Support Combined Arms Tactical Trainer (FSCATT -Phase II) – FSCATT Phase II is a distributed process, networked simulation which will provide combined arms collective training for Field Artillery units. FSCATT Phase I supports training of the Field Artillery gunnery team (forward observers, fire direction centers, and firing battery personnel) by providing them feedback on their proficiency while conserving fuel and ammunition. FSCATT Phase II will provide the capability to interoperate with other CATT systems. Additional manned modules will enable MLRS crews, resupply vehicles, Firefinder radars, and staff elements to conduct tactical fire support operations in a combined arms, computer simulated environment. Using common CATT components and DIS technology, FSCATT manned modules are capable of stand alone combined arms operations using SAF and emulator workstations. It is also capable of conducting training with other systems of the CATT family.

Home Station Training Instrumentation (HTI)

Description: HTI will build on the conceptual idea of Mobile Automated Instrumentation Suite (MAIS) and Precision Range Integrated Maneuver Exercise (PRIME) to create a state-of-the-art force-on-force instrumented range system for home station and deployed unit maneuver training. It will be a modular system capable of continuous support during normal exercise periods. For force-on-force exercises, HTI will include the Tactical Engagement Simulation System (TESS), and synthetic environment scenario-based OPFOR capabilities. It will also be used with the current and New Generation of Army Targets (NGATS), and precision gunnery systems in support of or in lieu of live fire exercises. The training support concept is based on the STX, FTX, and CALFEX. This includes exercise support up to 24 hours a day during a series of three to five day company team STX, an integrated CALFEX, and a battalion FTX during a 14-21 day battalion exercise cycle for

Active Component units or a 10-14 day cycle for non-mobilized Reserve Component units. The HTI will normally support 12-14 exercise cycles a year.

- Mobile Automated Instrumentation Suite (MAIS) is a fully mobile, high fidelity encrypted real-time casualty assessment and test instrumentation system. It accommodates five categories of player units - rotary wing, fixed wing, ground vehicles, crew served weapons and dismounted soldiers. MAIS is capable of supporting combined arms testing and training exercises of up to 1,800 participants.

- Precision Range Integrated Maneuver Exercise (PRIME) is a tactical trainer located at Fort Hood, Texas which trains fire and maneuver, command and control, target detection, identification, and engagement. PRIME instruments infantry and armor company team vehicles, OPFOR, pop-up targets, and dismounted infantry for realistic Multiple Integrated Laser Engagement System (MILES) based, force-on-force exercises. It provides controllable shoot-back targets for a free play environment and data collection to record crew through company level performance. Sufficient hardware to instrument an OPFOR is available for force-on-force exercises. Targets and player systems are linked through telemetry and a global positioning system (GPS) network to the C2 and AAR facilities, which are in transportable shelters. PRIME incorporates MILES II, Simulated Area Weapons Effects (SAWE), Telemetry Network, GPS, and Through Sight Video (TSV) technologies. For AARs, it provides audio and video recordings, computer generated statistics, and map graphics printouts.

Key Features of HTI:

- Provides the capability for objective data collection of subordinate unit performance in force-on-force of live fire exercises.

- Integrates live training with other simulation environments to provide representative training across all battlefield functions.

- Collates AAR materials from varied training support/simulations systems to provide a cohesive AAR package for the entire battalion task force or company team.

- Integrates or provides capabilities for exercise planning, exercise management, training performance feedback, scenario generation, sensor simulation and system support.

- Collects exercise data for the assessment of unit performance.

- Collects and records battle event data from BLUEFOR, OPFOR elements, and targetry.

- Conducts self-tests; monitors and controls the training exercise.

- Can be used for company teams and battalion FTXs and as the "live" battalion component of a higher unit synthetic exercise.

- Interfaces with models, simulations and simulators to simulate the Force XXI information management and warfare capabilities of the digitized force.

- HTI will interface with unit C4I systems, and present a realistic portrayal of the battlespace by simulating or stimulating sensors.

- OPFOR fire and maneuver in force-on-force can be portrayed by designated units conducting counter tasks and/or by CGF.